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Essays on Life Insurance and Healthcare Finance

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This dissertation consists of three essays examining issues related to life insurance and healthcare finance. In the first essay, we examine how R&D spending is influenced by prior year cash flow and corporate market value using a panel data set of medical device companies over the period 1962 to 2008. Based upon our findings, we show that the recently enacted excise tax on medical devices, taken alone, will reduce R&D spending by approximately $4 billion leading to a minimum loss of $20 billion worth of human lives.

In the second essay, we use the repeated sales regression method to construct an index of viatical/life settlement returns from 1993:Q4 to 2009:Q4. While these settlements outperform the S&P 500 by 2.04% annually, they display nearly twice the volatility. We find that despite the high standalone risk, the large return combined with low correlations and a lack of systematic risk exposure make viatical/life settlements extremely attractive investments when included in a well-diversified portfolio, particularly during times of economic crisis or downturn.

In the third essay, we build upon Ang and Liu (2004) to develop a term structure of the aggregate cost of capital for the medical device industry from 1963 to 2008. Using the term structure of cost of capital to value a 30-year $1.00 annuity we find a maximum valuation error of 37.46% and 53.66% when using the single period CAPM or Fama-French Three Factor model respectively. Additionally, we find a significant positive relation between the term structure of cost of capital spread and R&D intensity as well as equity issuance within the medical device manufacturing industry.

Essays on Life Insurance and Healthcare Finance

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Chapter 1:

Examining the Link Between Cash Flow, Market Value, and R&D Investment Spending in the Medical Device Industry

I. Introduction

Since long before George Washington's wooden teeth and Captain Ahab's peg leg, medical devices of all ilk have been intertwined with the human condition. While examples of our reliance upon medical innovation stretch back through history, the modern incarnation of the medical device industry has its roots in the 1930's (Monsein 1997). The Food, Drug, and Cosmetics (FD&C) Act, written by Agricultural Undersecretary Rexford Tugwell, was introduced by Senator Royal Copeland in 1933, and passed in 1938. The FD&C Act expanded the reach of the original Food and Drug Act of 1906, and brought the regulation of medical devices under the authority of the Food and Drug Administration (FDA) (Monsein 1997). Most importantly, this act formally defined medical devices as "instruments, apparatus and contrivances, including their components, parts and accessories, intended (1) for use in diagnosis, cure, mitigation, treatment, or prevention of disease in man or other animals; or (2) to affect the structure or any function of the body of man or other animals." More recently, the FDA altered the definition slightly to add that medical devices must achieve their purpose without chemical or drugs as their primary means.[1]

While medical devices range from the unassuming (tongue depressor and stethoscopes) to the astonishingly complex (drug exuding arterial stents and

[1] The current FDA definition - a medical device is "an instrument, apparatus, implement, machine, contrivance, implant, in vitro reagent, or other similar or related article, including a component part, or accessory which is: recognized in the official National Foundry, or the United States Pharmacopia, or any supplement to them; intended for use in the diagnosis of disease or other conditions, or in the cure, mitigation, treatment, or prevention of disease, in man and other animals; or intended to affect the structure or any function of the body of man or other animals, and which does not achieve any of its primary intended purposes through chemical action within or on the body of man or other animals and which is not dependent upon being metabolized for the achievement of any of its primary intended purposes." – source, FDA Website www.fda.gov

wireless pacemakers that communicates with doctors via the internet) the FDA uses 3 general categories to classify devices – Class 1, Class 2, and Class 3. Depending upon its classification (the details of which go beyond the scope of this paper) a device will either need a Premarket Notification (510k), or a Premarket Approval (PMA) to navigate the FDA and reach the market. Premarket Notifications are intended for devices that are substantially equivalent to existing, legally marketed, devices while Premarket Approvals are intended for devices that are extensively 'new'. Since 2000 the FDA has cleared over 37,700 501(k) premarket notifications for devices that represent incremental improvement over preexisting devices. During the same time frame, the FDA cleared only 392 Premarket Notifications for devices that are truly new and are not merely minor improvements on pre-existing devices.[2] While the pace of innovation in the industry is considered "rapid", the difference between FDA approvals for new devices versus improved devices illustrates the incremental nature of medical device innovation (Nexon and Ubl 2010).

Very little study of the medical device industry has been undertaken in the financial or economic academic arenas - particularly with regards to the determinants of research and development expenditures. This may be due, in part, to the fact that the medical device industry is overshadowed by its more glamorous sibling, the pharmaceutical industry. Countless articles have examined the pharmaceutical industry from every aspect imaginable. With specific regard to the determinants of research and development spending (R&D), most notable is the

[2] Source – FDA Website www.fda.gov

work of Grabowski (1968) and Grabowski and Vernon (1981, 1994, and 2000). Furthermore, several studies have probed the connection between drug prices, price regulation, and pharmaceutical R&D (Vernon 2005, Giaccotto, Santerre, and Vernon 2005, and Santerre, Vernon, and Giaccotto 2006).

However, while academia may have overlooked it, the medical device industry is not immune to the scrutiny of policy makers within the United States. Congress recently passed the Patient Protection and Affordable Care Act in an effort to reform healthcare in the United States. While the bill contains many facets that are plusses for both manufacturers and patients (payment disclosure, comparative effectiveness research, and expanded coverage) it also contains a 2.3% excise tax on medical device sales (Nexon & Ubl 2010). The new tax has raised vociferous objections from medical device manufactures claiming it will disadvantage U.S. firms forcing a reduction in sales, employment, and most of all innovation[3]. Despite these concerns there have been no studies designed to assess the impact of increased taxation on R&D expenditure. In fact, to our knowledge there has not been a single study examining the determinants of research and development within the medical device industry. While the pharmaceutical industry is significantly larger, and much more of a 'hot topic,' to completely ignore a sector with the proven past and promising future of the medical device industry seems injudicious - especially given the heated debate surrounding device manufacturers

[3] For example, see "Western Mass. Medical manufacturers express concern about 2.3% excise tax in new health care law", www.masslive.com,March 31, 2010; "Excise tax targets medical device makers", *Indiana Economic Digest, April 22, 2010;* "Proposed medical device tax causes concern", www.DOTmed.com, March 25, 2010; "Device makers react to healthcare reform bill's excise tax", www.massdevice.com, March 23, 2010.

and healthcare in general.[4] This paper seeks to fill this void by examining the determinants of R&D in the medical device industry as well as the impact of the newly enacted excise tax.

This paper is structured as follows. To place the rest of the paper in proper context, the next section describes the current state and market structure of the medical device industry. Section III constructs a theoretical model for the R&D investment decision and provides the specification of our empirical model. Section IV presents the empirical results as well as shows the impact of a proposed tax increase on the R&D of medical device manufacturers and the associated future lives lost. Finally, section V contains concluding remarks and discusses some other ways in which the new health care reform package may influence the R&D spending of medical device manufacturers.

II. Market Structure of the Medical Device Industry

As technology and medical advancements progress at blistering speed, the development and refinement of medical devices, and the extent to which we rely on them, will only increase. In 2007, the medical device industry[5] generated sales of over $105 billion on assets of over $180 billion. Between 1955 and 2007, the medical device sector experienced annual growth in total assets of 14.4% and annual growth in sales of 13.2%. Even in constant dollar, the annual growth rates

[4] However, the Nov/Dec 2008 issue of Health Affairs (Vol 27, No. 6, "The Price of Medical Technology) was primarily devoted to medical technology and the medical device industry.
[5] All firms with NAICs 334510, 334517, 339112, 339113, 339114

in assets and sales for the medical device industry are 9.25% and 8.11% respectively.[6]

Over the same 52 year period, the number of people employed in this industry grew from approximately 7,000 to 429,992 (which yields a 7.5% annual growth rate). Medical device sales have grown from 1.18% of national healthcare expenditures in 1960 to 4.70% of national healthcare expenditures in 2007.[7] This implies a 2.93% annual growth rate of medical device sales as a percent of total healthcare expenditures. Much of this growth (along with promising future growth estimates) is likely fueled by the aging of the US population. In 2005, 12.4% of the US population was above 65 years old; by 2050 the percent of US citizens 65+ is expected to increase to 20.7%. Across all developed nations, by 2050 33% of the population will be above the age of 60. It follows that the medical device industry stands to grow in both absolute and relative terms over the next several decades.

While the industry manufactures a broad range of products (quite literally from sutures to centrifuges), total revenues for medical device manufactures in 2009 can be sorted into the following five general categories (with revenue shares in parentheses): surgical appliances and supplies (40.6), surgical and medical instruments (36.3), laboratory apparatus and furniture (9.4), dental laboratory equipment (7.0), and dental equipment and supplies (6.7). While encompassing a wide range of products, the treatment of cardiovascular disease and orthopedics represent 60% of the industry's sales (MDDI 2008). Compared to other industries,

[6] The financial services firm Frost & Sullivan report a compound annual growth rate estimate of 9.0% for the years 2006-2013 (Business Wire, May 28, 2008)
[7] Centers for Medicare and Medicaid Services at cms.gov.

medical device manufacturing is quite lucrative. Between 2003 and 2008 medical device manufacturers experienced average profit margins of 60% - which is a 15% premium over the average gross margins for the firms in the S&P 500. Also, over that same time period, medical device manufactures reported earnings per share approximately 34% greater than the firms in the S&P 500 (MDDI 2008).

In terms of market structure, the medical device industry can be considered a bit of a conundrum. On the one hand, approximately 11,697 firms[8] operate in the medical device industry which results in a four-firm concentration ratio (CR_4) of approximately 39.2%. Economists typically consider an industry with a CR_4 under 40 percent as being reasonably competitive. Also, only 26 employees work in the typical medical device company.[9] On the other hand, depending upon the specific devices manufactured, the industry can be considered oligopolistic in nature. Specifically, some of the more specialized, complex, and expensive devices are manufactured by a relatively small sub-sector of the market that may not behave in a manner consistent with a market characterized by competitive conditions (Pauly and Burns 2008). As such, the firms manufacturing devices such as implantable cardioverter defibrillators, pacemakers, and some artificial joints fall into a market where the sellers offer products that are fairly similar but are not perfect substitutes for one another. The small number of firms operating in this arena, combined with the slight differentiation of their products, allows the manufacturers some control over the prices they charge. This market (or sub group of the medical device

[8] This figure varies depending up on the exact NAIC codes used to define 'medical device manufacturers'
[9] Industry figures obtained from IBISWorld Industry Report December 2009

market) is best described as a "differentiated oligopoly" (Pauly and Burns 2008). In general, the industry is slowly moving towards consolidation with larger firms readily purchasing smaller firms to acquire the latest technological advancements (MMDI Magazine Dec 2009). This merger and acquisition activity should lead to increasing profit margins as decreasing competition reduces pressure on prices.

Further encouraging the transition away from perfectly competitive conditions are the substantial barriers to entry in this industry. Sales, and therefore success, in the medical device industry are driven by the technological fruits of extensive research and development investment. Once a successful device is developed it is manufactured under patent, ensuring the un-infringed sale of the device for the life of the patent. Moreover, in addition to the tremendous investment in R&D needed to compete in this industry, all medical devices are regulated by the FDA. This extensive regulation, along with volumes of legislation concerning the production and implementation of medical devices, presents yet another barrier to entry for a prospective manufacturer and further diminishes competition. New firms seeking entry into the medical device industry must either spend tremendous amounts of cash on R&D to create a new product that does not violate any existing patents and clears extensive FDA regulations, or purchase an existing firm that has already done so. Either option for the new firm requires substantial capital investment.

III. The R&D Investment Decision

Any investment decision made by a firm will follow basic economic theory, and research and development is no exception. That is, the firm will stop investing once the return on the next dollar invested is eclipsed by the cost associated with raising that next dollar. The firm's marginal rate of return (mrr) schedule is determined by ordering all potential investment opportunities by decreasing risk-adjusted expected return; while the marginal cost of capital (mcc) schedule is determined by ordering the opportunity costs of all potential alternative investments in increasing order. Optimal research and development spending, RD*, is found at the intersection of the *mrr* and *mcc* curves. We can determine RD* algebraically by solving the following equation:

$$\text{mrr}(\text{RD}, \text{X}) = \text{mcc}(\text{RD}, \text{Y}), \tag{1}$$

where RD equals research and development expenditure, X stands for a vector of variables exerting influence on the expected returns to R&D (i.e. factors that increase marginal return) and Y represents a vector of variables exerting influence over the opportunity cost of alternative investments (i.e. factors that increase marginal cost). Solving for the optimal research and development RD*, the following reduced-form equation can be obtained:

$$\text{RD}^* = \text{f}(\text{X}, \text{Y}) \tag{2}$$

In equation (2) we can see that RD* is a function of the variables that impact the expected return on R&D, (X), and the variables that impact the cost of raising the funds spent on research and development, (Y). Thus, R&D is determined by external

factors shaping how much a firm benefits from each dollar spent on R&D and exogenous forces influencing how much it costs to raise each dollar spent.

Prior research on the pharmaceutical industry examines R&D spending on two broad levels. First there is a macro-level examination that seeks to explain variations in R&D across the entire pharmaceutical industry over time (Scherer 2001; Giaccotto, Santerre and Vernon 2005). A frequent offshoot of this macro-level R&D research examines the impact of government regulations and price controls on the level of R&D spending and its subsequent impact on society (Santerre, Vernon, and Giaccotto 2006). The second stream of R&D research focuses on firm-level R&D (Grabowski 1968; Grabowski and Vernon 1981, 2000; Vernon 2002, 2004, and 2005). The model in this paper stems primarily (although not entirely) from this second branch of R&D research.

Equation (2) points out that a firm's decision to invest in research and development is driven by two vectors of variables, X and Y. First, there are the variables that impact the productivity of R&D investment; these variables reside in the X vector, and typically measure return on the funds invested in research and development. Unfortunately, it is exceedingly difficult to calculate ex ante returns on current R&D spending; as such, prior studies have employed various measures of productivity and return. The earliest R&D research used patents per researcher and the extent of product diversification (Grabowski 1968). More recent work uses several measures of contemporaneous return such as, profit margin, industry margin, and new product sales (Vernon 2005, Grabowski and Vernon 2000, Mahlich and Roediger-Schluga 2006).

Yet another wrinkle in determining the variables for the X vector comes from Lichtenberg (2001, 2004). Lichtenberg points out that "many economists would not hypothesize a contemporaneous relationship" between measures of profits and R&D investing. Guided by the assumptions that capital markets are perfect, and that financial managers seek to maximize shareholder's wealth, investment in research and development should depend primarily on expected future profits as opposed to current profits. According to discount cash flow theory, current firm value can be interpreted as the present value of all future profits. This relationship between R&D investment and firm value can be traced back to John Maynard Keynes, who first hypothesized that investment decisions may depend upon firm value, and James Tobin who laid out the theoretical framework for this hypothesis (Lichtenberg 2004).[10]

The second vector of variables, Y, impacts the firm's cost of raising capital with which to invest in R&D opportunities. Academic research has repeatedly shown that the presence of transaction cost, tax issues, agency concerns, and a host of other issues create a significant discrepancy between the costs of internal funds

[10] Some of the return on' R&D variables used in prior pharmaceutical studies would not translate well to the medical device industry. Specifically, the variable measuring funds generated from the sale of highly successful new drug creations. The pharmaceutical industry is heavily reliant upon massively successful 'blockbuster' drugs. These blockbuster drugs generate huge amounts of revenue for pharmaceutical firms and allow these firms to weather the large number of failures that vastly outweigh their successes. Innovation in the medical device industry is a much more iterative process. Medical device firms do not rely on one or two blockbuster products to fund their failures and ensure profits. Rather, most advancement comes in the form of small improvements to existing devices. Recall that between 2000 and 2008, only 392 'new' products have passed through the FDA's approval process, while over 37,700 incrementally improved devices have been approved during that time period. Therefore, the medical device industry is not dependent upon the 'blockbuster' product to support R&D investment. So, the characteristics of our sample, the machinations of the medical device industry, and Lichtenberg's 2001 comment support the choice of contemporaneous firm value for our 'return' variable.

and external funds used to finance investment (Fazzari, Hubbard, and Peterson 1988; Hall 1992; and Hubbard 1998). In both the earlier and current pharmaceutical R&D research, lagged cash flow, before dividends and investment, has been used to measure the level of internally-available funds (Grabowski 1968, Grabowski and Vernon 2000; Vernon 2005; Mahlich and Roediger-Schluga 2006, and many others). Given its lower cost, firms with larger stores of internal funds should have correspondingly larger levels of research and development investment. Unlike the components of the return on R&D, or vector (X), the manner in which researchers have calculated internally-available cash flows, or vector (Y), has changed very little over the years.

The forthcoming analysis of medical device research and development spending will utilize a model loosely based upon Vernon's (2005) exploration of the relation between R&D investment and price regulation. Like Vernon we measure the return gained from research and development spending using a firm-level rather than an industry-level measure of return as industry-level measures are inappropriate for a sample of heterogeneous firms (Vernon 2005). However, unlike Vernon's (2005) model, contemporaneous firm value is used to proxy for the expected return on R&D investment as suggested by Lichtenberg (2001, 2004).[11]

[11] Vernon (2005) specifically considers this approach but ultimately rejects it as less than ideal for the pharmaceutical industry. Most of the firms in the pharmaceutical industry (and therefore most of the firms in Vernon's sample) are not exclusive to the pharmaceutical industry. Rather, the majority of these firms operate in a diverse range of industries. This diversification could obfuscate the relation between firm value and pharmaceutical R&D as some of the changes in firm value could be due to R&D investment in other business segments. However, our data set consists of 34 firms that operate primarily (if not exclusively) within the medical device manufacturing industry. We can safely conclude that any contemporary changes in firm value due to R&D stem solely from medical device R&D. In creating this data set we have identified a set of firms that warrant firm level examination, while ensuring that these firms are not 'conglomerate' firms that spread R&D

Thus, the following general model can be specified to explain the R&D of medical device firms with CF, Value, and TA representing the cash flow, market value and total assets (or size) of each firm during each period.

$$RD_{i,t} = g(CF_{i,t-1}, Value_t, TA_{i,t-1}) \quad (3)$$

We specify the actual level of R&D, as opposed to the more traditional research intensity measure (R&D scaled by sales), due to the nature of the medical device firm data. Several of the firms in our sample have a number of years where R&D completely consumes sales, and in many cases significantly exceeds sales. R&D intensity in our sample ranges from 0.00 to 275.00 percent of sales. One method to deal with these extreme observations is to treat them as inconsequential outliers and eliminate them entirely or to windsorize them at some much lower level. For example, Cazier (2008) eliminates all observations where R&D intensity exceeds 40% of sales. However, these extreme observations in the medical device firm data are far from erroneous. Our sample begins in 1962 with 11 firms and grows to 34 firms by 1985, many of these firms experience periods of high R&D with low sales as they initially develop and establish their products. These firms would necessarily have extremely large R&D intensity values that might distort our results.[12] Our use of the actual level of each variable allows us to include all of our data without fear of skewing our analysis with 'outliers' as well as eliminate any selection bias that

investment funds across a wide range of projects and would therefore contradict the use of firm value as championed by Lichtenberg (2001, 2004).

[12] As a robustness check we evaluated our model using a sub-set of our data that did not contain any extreme outliers for any of the traditional RDS and CFS variables and obtained qualitatively identical results.

might be introduced by truncating our data (bounding it between say, 0 and 0.40 or 0 and 1.0).

The $CF_{i,t-1}$ variable is intended to measure the lagged amount of each firm's internally-available cash flow during each period, i.e. the (Y) vector variable that impacts the supply of R&D funds. It is calculated by summing net income, depreciation and after-tax R&D investment. The use of after-tax R&D investment is necessary because R&D is expensed unlike other capital assets. By adding back after-tax R&D the proper "pre-investment" cash flows can be calculated (Hall 1992; and Grabowski and Vernon 2000). To calculate after-tax R&D, a flat 33% tax rate is used (Grabowski and Vernon 2000). We calculate firm value as the sum of the market value of equity plus the book value of long-term debt plus the liquidation value of preferred shares for each firm for each year. Our use of levels, as opposed to ratios, for our variables necessitates including a variable to control for firm size. It is natural to assume that larger firms will have larger R&D investment budgets. Furthermore, past research has documented a significant connection between firm size and R&D investment (Shumpeter 1942, Tsai 2005; Tsai and Wang 2005, Lee and Sung 2005, and Chang and Robin 2006). Therefore, we include total assets in our regression to control for firm size.

Unfortunately, like many financial and economic time series, our data set is non-stationary and contains unit roots. The presence of unit roots in our data could lead to spurious regression results (driven by a high degree of correlation between two variables but lacking any causality) with high R^2 and t-statistics and little, if any, economic interpretation (Granger and Newbold 1974). In other words, without

correcting for the presence of unit roots in our data, we would have regression results that 'look good' but contain little or no value. To correct for the presence of unit roots in our data, we rely in a traditional and effective cure – using a first difference model. That transformation results in a specific form for our final estimation equation.

$$d(RD_{it}) = \beta_1 + \beta_2 * d(CF_{it-1}) + \beta_3 * d(Value_{it}) + \beta_4 * d(TA_{it-1}) + \varepsilon_{it} \quad (4)$$

Where, RD_{it} = R&D investment of firm i during year t

CF_{it-1} = internal cash flow of firm i during year t-1

$Value_{it}$ = firm value of firm i during year t

TA_{it-1} = total assets of firm i during year t-1

ε_{it} = error term.

and, $d()$ represents the difference operator

The data used to estimate equation 4 come from consolidated income and balance sheet statements found on Standard and Poor's Compustat database. We identified 34 firms that exclusively or at least primarily operate within the medical device manufacturing industry. The sample is an unbalanced panel starting in 1962 and continuing to 2008 and contains a total of 759 usable firm-year observations.

IV. **Empirical Results**

Table 1 panel 'A' presents summary statistics for the entire sample of firms used in this paper; while panels 'B' and 'C' present summary statistics for sub

periods 1962-1985 and 1986-2008 respectively. For the entire sample of 34 firms, only 11 are present in the 1st sub period (1962-1985), indicating that most of the firms are relatively young. This could also be evident in the significantly increased volatility of our variables over time. One would expect that average investment, cash flows, assets, and sales would increase quite a bit over the sample period (1962 – 2008); however, we also see a tremendous increase in the volatility of these variables as indicated by their standard deviation.

Table 2 presents the unbalanced efficient generalized least squares (EGLS) panel regression using both period and cross-sectional fixed effects results for equation (4) with column 2 showing the results for the entire sample and column 3 showing the results for the 1962-2008 sub-period, and finally, column 4 showing the results for the 1986-2008 sup-period. EGLS allows the data to determine the specific form of any heteroskedasticity or serial correlation. Several observations can be drawn from Table 2. First, for the entire sample, after controlling for firm size we can see that the medical device firm's decision to invest in R&D is indeed influenced by the X and Y vectors from equation (2). The amount of internal cash flows is a significant factor in R&D spending. In fact, with a coefficient of 0.202, an increase of $1000 of internal cash flows results in an increase in research and development investment of $202. This strong relation between cash flow and research and development is significant at the 1% level, and is similar to what has been found in past pharmaceutical research. If we turn to the influence of firm value on R&D, we find another strongly significant relationship (1% level or better). Here, a $1000 increase in firm value will increase R&D by $7.12.

Second, except for the effect of firm size, similar results are obtained for the two sub-periods (1962-1985 and 1986-2008). For the earlier period a $1000 increase in internal cash flows or firm value will cause a $67.19 or $5.93 increase in R&D, respectively – both significant at the 1% level or better. While the 1962–1985 period maintains the statistical significance, the magnitude, or economic impact of our independent variables is diminished quite a bit, especially for our cash flow variable. We see similar results for later time period (1986-2008), except it is the firm value variable that has a diminished economic impact. Here we see that a $1000 increase in cash flow or firm value will result in a $184.38 or $4.23 increase in R&D investment.

Looking back to the entire sample again, we can calculate an elasticity of research and development investment with respect to our two variables of interest. First, using mean (median) values and the 0.202 regression coefficient, we calculate that the elasticity of R&D investment with respect to cash flow is .5784 (.4311). Also using mean (median) values we calculate an elasticity of 0.3081 (0.2639) with respect to firm value. Table 2 reports the elasticities for R&D Investment with respect to cash flow and firm value for the entire sample as well as both sub periods using both mean and median values. We can see that for the earlier sub period (1962-1985) the impact on R&D investment of a 1% increase in both firm value and internal cash flows are quite similar when using mean values, and using median values the impact from firm value is greater than the corresponding increase in cash flow. The greater impact on R&D from firm value in the earlier period could be indicative of younger, smaller, firms that have not yet generated substantial cash

flows, but are investing heavily in R&D on the perceived future profits generated by such investment.

Lichtenberg (2004) finds R&D investment elasticities of 0.114 and 0.225 with respect to cash flow and firm value, respectively, for the pharmaceutical industry. Regardless of our choice of mean or median values, we find that a 1% change in either cash flows or firm value have a significantly greater impact on R&D investment in medical device firms than in pharmaceutical firms. Furthermore, the elasticity of R&D with respect to cash flows and value we found for the medical device industry are significantly larger than those found in several other industries: energy (0.103, -0.002); commodity chemicals (0.096, 0.122); life sciences (-0.012, 0.063); and other chemical (0.037, 0.146) (Arora, Ceccagnoli, and Da Rin 2000). [13]

On March 21, 2010 the House of Representatives passed HR 3590, the 'Healthcare Reform Bill' which includes an excise tax of 2.3% on the sales of medical device firms starting in 2013. The industry is understandably concerned about the impact of this tax. Recent speculation points towards loss of profits, loss of jobs, attrition of firms, and most important for this paper, a significant reduction in research and development[14]. With such a sizable decrease in revenues, we can envision the 2.3% excise tax working in two ways.

First, the decrease in revenues may result in lower internal cash flows available for investment (the model's Y vector). Second, persistently lower revenue will necessarily result in a decrease in firm value. Since a firm's current value can be

[13] Arora, Ceccanoli, and Da Rin (2000) do not use total firm value as we have defined it in this paper; rather the R&D elasticities reported above are for R&D investment with respect to *equity value*.
[14] See footnote 3 for articles describing the medical device industry's views towards the new tax

thought of as the present value of all future cash flows, it is clear to see that as we reduce those cash flows we also reduce the firm's value (the model's X vector). Finally, the additional tax burden of 2.3% of sales may also increase the firms' discount rate (expected cost of capital) used to translate future cash flows into current firm value. So, the excise tax will reduce firm value by acting on both the numerator and denominator of the dividend (cash flow) discount model in addition to reducing the current level of cash flow available.

To quantify the impact of this tax on research and development investment we will examine forecasts of R&D over ten years beginning in 2013 (the first year the tax is implemented). These forecasts will be compared to a base scenario with no excise tax. Both scenarios will begin with estimates of our dependent variables using the long-run average growth rates for each data series between 2013 - 2023. Although no specific sales figures are referenced, the excise tax only applies to "taxable medical devices" and provides for several exemptions. Specifically, devices that are purchased for use aboard aircraft and other vessels, for use by state or local government, for use by a nonprofit organization, or for use by qualified blood collectors[15] Without knowing the exact mechanizations of the tax's implementation we can examine the impact of 2.3% excise tax assuming 1%, 5%, 10%, and 15% exempted sales. Furthermore, we are unable to determine what percentage of the increased tax burden will be passed on to the consumer and what percentage will be retained by the industry. Therefore, we conduct our analysis assuming the industry's tax burden is 5%, 15% or 25% of the 2.3% excise tax.

[15] See KPMG 2010 "What's New in Tax – New Excise Tax on Medical Devices June 7, 2010. By Deborah Karet and Ruth Hoffman.

The annual and cumulative dollar amount of foregone R&D investment due to the excise tax are shown in table 3, with panels A, B, and C corresponding to industry burden levels of 5%, 15%, and 25% respectively. We can see that the new excise tax will eliminate between nearly $1.3 and $7.3 billion of cumulative R&D between 2013 and 2023. Table 4 shows the tax impact on R&D in terms of current (2010) dollars is between $690 million and $3.69 billion.

In similar research examining the impact of government price controls on pharmaceutical R&D, Santerre, Vernon, and Giaccotto (2006) turn from the dollar value of lost R&D to it cost to U.S. citizens. To do this Santerre, Vernon, and Giaccotto use Lichtenberg's estimate of $1,345 of pharmaceutical R&D spending needed to gain a single life year (Lichtenberg 2002) and calculate how many life years were lost due to depressed R&D spending. While Lichtenberg's figure pertains to pharmaceutical R&D spending, we are able to use Neumann, Sandberg, Bell, Stone, and Chapman's (2000) median estimate of $40,000 cost per quality adjusted life year (QALY) gained for medical devices to calculate a reasonable estimation of R&D spending needed to gain one QALY. Using 2007 median estimates for RDS along with the 2007 adjusted median estimate of $51,444 cost per QALY, and the 2007 average RDS of 0.06, we are able to calculate an estimate of $3,087 of R&D spending needed to gain one QALY. Following Santerre, Vernon, and Giaccotto (2006) we are able to now calculate the number of quality adjusted life years lost as well as the economic impact of those lost QALYs.

Table 5 shows the life years lost for each estimation of the industry's burden of the new tax using our $3,087 calculation of R&D spending needed to gain one

quality adjusted life year as well as several multiples of that figure. We can see, depending upon industry's actual tax burden and the estimate of medical device R&D spending needed to gain one quality adjusted life year, the proposed tax will cost between 106,737 and 2,379,769 quality adjusted life years. With reasonable estimates (using $3,087 of R&D spending to save one QALY) ranging from 213,473 to 1,189,885 quality adjusted life years

Finally, we can calculate the dollar value of the life years lost due to increased taxation depressing medical device R&D spending. There is some controversy surrounding the actual value of one human life year (Santerre, Vernon, and Giaccotto 2006). Recent research has estimated the value of one human life year for a U.S. citizen be $100,000 (Cutler 2004), between 250,000 and 300,000 (Murphy and Topel 2003) and to range from $169,000 to $731,000 depending upon parameter inputs, with reasonable estimates ranging from $193,000 to $360,000 (Murphy and Topel 2006). In their 2006 paper Santerre, Vernon, and Giaccotto use a range of $50,000 - $150,000 to calculate the dollar value of life years lost. In that same spirit, we use a range of $200,000 to $300,000 to calculate the dollar value of life years lost to depressed medical device R&D spending.

Table 6 presents range for each assumed industry tax burden percentage. While there is much uncertainty regarding exempt medical device sales, the industry's burden from the tax as well as uncertainty regarding the amount of medical device R&D spending needed to gain one life year and the subsequent dollar value of that life year, we can see that even using the minimum assumptions the dollar value of the life years lost as a result of increased taxes will be $21 billion. In

fact, across all our assumption the total value of the potential life years lost to increasing taxes will range from $21 to $714 billion. Even using the lowest dollar value per human life year we estimate between $21 billion and $476 billion worth of lost lives between 2013 and 2023 as a result of the excise tax.

V. Conclusion

In this paper we examined the previously overlooked medical device industry by applying the framework successfully established in decades of pharmaceutical industry research. Specifically, we examined the determinants of R&D investment by medical device manufacturers. As found in the pharmaceutical industry, the availability of internally generated funds is a significant determinant of research and development spending for our entire sample of medical device firms. Since internal cash flows are cheap relative to external financing, R&D spending will be higher when larger amounts of internal funds are available.

While most of the past research has relied upon some measure of contemporaneous return to proxy for the expected future returns on R&D spending, we deviate slightly and use contemporaneous firm value. Theoretically, the value of the firm today depends up on the present value of all future profits, and in an industry such as medical devices much of these future profits stem from research and development. This paper has shown that firm value is indeed a significant determinant of research and development spending for medical device firms. Additionally, the elasticity of research and development investment with respect to

both cash flows and firm value within the medical device industry far exceed those of the pharmaceutical industry.

This article is also the first to investigate the potential R&D investment impact of a recently passed excise tax on the medical device industry. By examining forecasts of future R&D expenditures, we are able to estimate the amount of foregone R&D expenditures from an increase in the tax rate. Our estimates suggest that R&D spending will fall by between $1.3 and $7.2 billion as a result of the 2.3% tax on revenue included in the recent healthcare reform bill. This lost R&D spending translates into a loss of up to 2.4 billion life years (years of human life that could have been 'saved' by the advancements discovered through medical device R&D). Finally, using a range of estimates for the dollar value of one human life year, we estimate that the life years lost through increased taxation will cost society between $21 and $714 billion between 2013 and 2023.

In the preceding examination we examined the impact of the 2.3% excise tax on medical device sales that is a part of the newly passed Patient Protection and Affordable Care Act. While the tax may be the largest concern (as well as the easiest to examine), it is by no means the only facet of the Act that impresses upon the medical device industry. In their recent examination of the Act's impact on the medical technology industry, Nexon and Ubl (2010) quickly point out that there are both positive and negative ramifications of the act other than the excise tax that influence the X vector and/or Y vector of our model and therefore impact research and development spending.

Nexon and Ubl (2010) highlight several potential positive industry impacts found in the new legislation. The clear leader of these is the expansion of coverage to the previously uninsured in 2014. As the number of individuals with healthcare coverage increases so does the customer base for medical device manufacturers[16] Second is the legislation's emphasis on reducing adverse conditions and infections acquired during health care. The Act will use the rate of conditions/infections acquired as a performance metric in the evaluation of hospital Medicare payments. This will increase demand for devices that reduce the incidents of adverse conditions/infections as well as those devices used in the detections of contagions. Next, the Act calls for expanding coverage for preventative care for all insured individuals (including those currently covered). This should increase demand for imaging and diagnostic devices.

Clearly, any measure contained within the new legislation that amplifies demand has the potential to increase both the X and Y vectors of our model. As demand drive revenue, firms will see an immediate increase in the funds available for R&D investment (our X vector). Furthermore, investors in firms manufacturing the high demand devices will begin to demand higher expected returns (our Y vector). Nexon and Ubl (2010) also point to comparative effectiveness research as a net positive for the industry – some devices will lose customers while other will gain customers. The impact on our model is less clear. Higher research costs could reduce both the X and Y vectors and the fruits of that additional research may or may not impact either of the vectors (negatively or positively).

[16] We should note here that Nexon and Ubl (2010) pint out that the resulting increase in medical device spending will most likely be lower than the increase in general healthcare spending.

In addition to the 2.3% excise tax, the Patient Protection and Affordable Care Act contains a few other features that appear to have a negative impact on the medical device industry. First, the legislation aims to cut Medicare payments to providers by $272 billion. Since it is the providers who pay for medical devices (as opposed to Medicare paying directly), these cuts will be passed on to the industry in the form of increased price pressure and delayed purchases. Lower prices and delayed sales will result in lower funds available for investment (X vector), and, if persistent, lower expectation of future profits/returns (Y vector).

Finally, the Patient Protection and Affordable Care Act also contains some new payment provisions designed to stem the growth in health care costs and improve care. While reducing cost and improving care are desirable goals, Nexon and Ubl (2010) caution that too great an emphasis on cost reduction could lead to "a cheapest-is-best approach" to health care – including the implementation of devices. Also, heavy stress on cost reduction, if not properly implemented runs the risk of freezing technological advancement (Nexon & Ubl 2010). Future research in this area might examine the impact to medical device R&D and the resulting human and dollar impact to society stemming from other aspects of the Patient Protection and Affordable Care Act.

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Tables

Table 1:
Summary Statistics for Medical Device Manufacturers

Panel A: Entire Sample 1962-2008					
	CF	**RD**	**TA**	**VALUE**	**SALES**
Mean	988.02	344.97	11,275.96	14,921.46	6,254.80
Median	41.49	19.44	323.36	720.15	337.71
Maximum	34,441.85	8,487.00	797,769.00	689,255.30	180,929.00
Minimum	-7,292.12	0.00	0.07	0.08	0.00
Std. Dev.	3,116.14	955.18	60,166.51	57,241.98	18,401.57
No. of Firms	34	34	34	34	34
Firm Years	759	759	759	759	759

Panel B: 1962-1985					
	CF	**RD**	**TA**	**VALUE**	**SALES**
Mean	235.36	90.43	1,724.41	2,458.76	2,000.37
Median	26.12	14.01	209.39	433.29	242.83
Maximum	4,256.85	1,456.00	26,432.01	33,925.25	28,285.01
Minimum	-17.69	0.02	0.35	0.25	0.01
Std. Dev.	559.02	214.52	4,154.24	4,373.58	4,752.62
No. of Firms	11	11	11	11	11
Firm Years	147	147	147	147	147

Panel C: 1986-2008					
	CF	**RD**	**TA**	**VALUE**	**SALES**
Mean	1,428.72	446.00	16,774.78	20,131.78	8,716.75
Median	96.68	24.74	664.06	1,229.48	720.21
Maximum	34,441.85	8,487.00	797,769.00	689,255.30	180,929.00
Minimum	-7,292.12	0.00	0.07	0.10	0.00
Std. Dev.	3,819.86	1,098.45	74,809.56	67,345.53	22,415.29
No. of Firms	34	34	34	34	34
Firm Years	612	612	612	612	612

Table 2:

Unbalanced EGLS Regression Findings			
Dependent Variables RD (R&D investment)			
	1962-2008	**1962-1985**	**1986-2008**
Variable	**Coefficient (t-statistic)**	**Coefficient (t-statistic)**	**Coefficient (t-statistic)**
D(CF(-1))	0.20195	0.067185	0.184375
	(8.0339)	(3.0463)	(6.5066)
D(VALUE)	0.007122	0.005927	0.004231
	(3.8330)	(6.9387)	(2.0269)
D(TA(-1))	-0.128145	0.022794	-0.138405
	(-19.4915)	(3.9065)	(-22.5250)
R-squared	0.455095	0.654328	0.486453
Adj R-squared	0.45293	0.647076	0.483919
F-statistic	210.1878	90.2291	191.9746
Prob(F-stat)	0	0	0
No. Firms	34	11	34
No. Periods	46	23	23
No. Firm Years	759	147	612
Mean Elasticities			
CF	0.5784	0.1749	0.4799
Value	0.3081	0.1612	0.1150
Median Elasticities			
CF	0.4311	0.1252	0.3436
Value	0.2639	0.1833	0.1308

Table 3:

Lost R&D Investment Due to Increased Tax

Panel A: Annual and Cumulative Lost R&D Investment (5% Industry Burden)

	Percent Sales Exempt			
Year	**1%**	**5%**	**10%**	**15%**
2013	$46.87	$45.00	$42.67	$40.33
2014	$86.80	$83.33	$78.99	$74.64
2015	$100.09	$96.09	$91.08	$86.07
2016	$110.72	$106.29	$100.75	$95.21
2017	$121.90	$117.03	$110.93	$104.82
2018	$134.15	$128.79	$122.07	$115.36
2019	$147.64	$141.74	$134.35	$126.96
2020	$162.51	$156.02	$147.89	$139.75
2021	$178.90	$171.75	$162.80	$153.84
2022	$196.97	$189.09	$179.24	$169.37
2023	$216.88	$208.21	$197.36	$186.50
Cumulative Total	$1,503.45	$1,443.34	$1,368.13	$1,292.84

Panel B: Annual and Cumulative Lost R&D Investment (15% Industry Burden)

	Percent Sales Exempt			
Year	**1%**	**5%**	**10%**	**15%**
2013	$136.41	$131.14	$124.52	$117.87
2014	$254.93	$244.94	$232.41	$219.85
2015	$294.09	$282.56	$268.10	$253.60
2016	$325.31	$312.55	$296.56	$280.52
2017	$358.13	$344.09	$326.49	$308.83
2018	$394.10	$378.65	$359.28	$339.85
2019	$433.71	$416.70	$395.39	$374.01
2020	$477.35	$458.64	$435.19	$411.66
2021	$525.45	$504.86	$479.04	$453.15
2022	$578.47	$555.80	$527.38	$498.87
2023	$636.91	$611.95	$580.67	$549.29
Cumulative Total	$4,414.85	$4,241.87	$4,025.03	$3,807.50

Panel C: Annual and Cumulative Lost R&D Investment (25% Industry Burden)

	Percent Sales Exempt			
Year	**1%**	**5%**	**10%**	**15%**
2013	$220.77	$212.47	$202.03	$191.51
2014	$416.27	$400.26	$380.16	$359.96
2015	$480.43	$461.94	$438.72	$415.39
2016	$531.42	$510.96	$485.28	$459.47
2017	$585.00	$562.49	$534.22	$505.81
2018	$643.71	$618.94	$587.84	$556.59
2019	$708.36	$681.11	$646.89	$612.50
2020	$779.59	$749.60	$711.95	$674.11
2021	$858.08	$825.08	$783.64	$742.00
2022	$944.59	$908.27	$862.66	$816.83
2023	$1,039.95	$999.97	$949.77	$899.31
Cumulative Total	$7,208.18	$6,931.09	$6,583.16	$6,233.47

Table 4:
Lost R&D Investment Due to Increased Tax (in 2010 Dollars)

Panel A: Annual and Cummulative Lost R&D Investment (5% Industry Burden)

	Percent Sales Exempt			
Year	**1%**	**5%**	**10%**	**15%**
2013	$37.21	$35.73	$33.87	$32.01
2014	$63.80	$61.25	$58.06	$54.86
2015	$68.12	$65.40	$61.99	$58.58
2016	$69.77	$66.98	$63.49	$60.00
2017	$71.13	$68.28	$64.72	$61.16
2018	$72.48	$69.58	$65.95	$62.32
2019	$73.86	$70.91	$67.21	$63.51
2020	$75.28	$72.27	$68.50	$64.73
2021	$76.73	$73.66	$69.82	$65.98
2022	$78.22	$75.09	$71.18	$67.26
2023	$79.75	$76.56	$72.57	$68.58
Cumulative Total	$766.34	$735.70	$697.37	$658.99

Panel B: Annual and Cumulative Lost R&D Investment (15% Industry Burden)

	Percent Sales Exempt			
Year	**1%**	**5%**	**10%**	**15%**
2013	$108.29	$104.10	$98.85	$93.57
2014	$187.38	$180.03	$170.83	$161.60
2015	$200.15	$192.30	$182.47	$172.60
2016	$205.00	$196.96	$186.88	$176.78
2017	$208.97	$200.77	$190.50	$180.20
2018	$212.92	$204.57	$194.11	$183.61
2019	$216.96	$208.46	$197.79	$187.10
2020	$221.11	$212.44	$201.58	$190.68
2021	$225.36	$216.52	$205.45	$194.35
2022	$229.72	$220.71	$209.43	$198.11
2023	$234.19	$225.01	$213.51	$201.97
Cumulative Total	$2,250.03	$2,161.89	$2,051.40	$1,940.55

Panel C: Annual and Cumulative Lost R&D Investment (25% Industry Burden)

	Percent Sales Exempt			
Year	**1%**	**5%**	**10%**	**15%**
2013	$175.25	$168.66	$160.38	$152.03
2014	$305.97	$294.20	$279.43	$264.58
2015	$326.97	$314.39	$298.59	$282.71
2016	$334.88	$321.99	$305.81	$289.54
2017	$341.34	$328.21	$311.71	$295.14
2018	$347.78	$334.39	$317.59	$300.71
2019	$354.36	$340.72	$323.60	$306.40
2020	$361.10	$347.21	$329.77	$312.24
2021	$368.02	$353.86	$336.09	$318.23
2022	$375.11	$360.69	$342.58	$324.37
2023	$382.39	$367.69	$349.23	$330.67
Cumulative Total	$3,673.17	$3,532.02	$3,354.77	$3,176.63

Table 5:

Quality Adj. Life Years Lost Due to Foregone R&D Spending

Panel A: Industry Pays 5% of Tax Burden

R&D Spending to Save One Life Year	Percent Sales Exempt			
	1%	5%	10%	15%
$3,087	***248,247***	***238,323***	***225,905***	***213,473***
$1,544	496,494	476,645	451,810	426,946
$2,315	330,996	317,764	301,206	284,631
$4,631	165,498	158,882	150,603	142,315
$6,174	124,124	119,161	112,952	106,737

Panel B: Industry Pays 15% of Tax Burden

R&D Spending to Save One Life Year	Percent Sales Exempt			
	1%	5%	10%	15%
$3,087	***728,873***	***700,321***	***664,528***	***628,621***
$1,544	1,457,747	1,400,641	1,329,056	1,257,243
$2,315	971,831	933,761	886,037	838,162
$4,631	485,916	466,880	443,019	419,081
$6,174	364,437	350,160	332,264	314,311

Panel C: Industry Pays 25% of Tax Burden

R&D Spending to Save One Life Year	Percent Sales Exempt			
	1%	5%	10%	15%
$3,087	***1,189,885***	***1,144,159***	***1,086,742***	***1,029,033***
$1,544	2,379,769	2,288,318	2,173,484	2,058,067
$2,315	1,586,513	1,525,545	1,448,989	1,372,045
$4,631	793,256	762,773	724,495	686,022
$6,174	594,942	572,079	543,371	514,517

Table 6:

Dollar Value of Life Years Lost (in Billions)

Estimated Value	Percentage of Tax Paid by Industry								
Per Life Year	5%			15%			25%		
$200,000	21	to	99	63	to	292	103	to	476
$250,000	27	to	124	79	to	364	129	to	595
$300,000	32	to	149	94	to	437	154	to	714

Chapter 2:

The risk and return characteristics of life insurance policies on the secondary market:

Examining the Viatical and Life Settlement Industry

I. Introduction

This is the first paper to explicitly examine the risk and return characteristics of individual life insurance policies purchased in the secondary market – typically the policies owned by terminally ill patients (viatical settlements) or the elderly (life settlements). The late 1980's and early 1990's saw the development of a secondary market for individual life insurance policies. This not only allowed individuals (i.e. the original purchaser of the life insurance policy) to access substantial amounts of cash that were previously tied up in an extremely non-liquid asset, it also created a market for a new kind of asset. However, despite nearly 25 years of viatical/life settlement activity, virtually nothing is known about these assets as potential investment opportunities. This paper seeks to remedy this, by filling the void in viatical and life settlement analysis.

Specifically, this paper adapts the repeat sales regression method to develop a quarterly index of viatical/life settlement returns from 1993:Q4 through 2009:Q4. The methodology is roughly the same as that used to compute the S&P Case Shiller real estate price index widely quoted in the public media to measure the health of local housing markets throughout the U.S. The estimated index reveals that viatical/life settlements earn 2.04% higher annualized returns compared to the S&P 500, but are 2.0 times more volatile. However, we find that despite the high stand-alone risk, these settlements are not subject to the same systematic risk found in nearly all other assets. Correlations with traditional assets (small stocks, large stocks, and corporate bonds) are low and CAPM analysis shows an insignificant beta.

From this standpoint of high return, low correlations, and a beta not statistically different than zero, we examine the role of viatical/life settlements in well-diversified portfolios. This paper find that the inclusion of viatical/life settlements in typical investment portfolios leads to increased returns and, for less risk adverse investors, decreased volatility. We also find that portfolios with these settlements achieve larger alphas and lower betas over our sample period. Furthermore, in times of economic crisis or downturn portfolios with viatical/life settlements performed considerably better than portfolios without them. Specifically, all portfolios with these settlements had consistently higher returns and substantially lower volatility.

The rest of this paper is organized as follows. Section 2 describes what viatical and life settlements are and provides some background on the modern incarnation of the viatical settlement industry in the United States. Section 3 reviews the existing literature surrounding the viatical settlement market. Section 4 describes the data used in this analysis and presents the repeat sales framework used to create a quarterly index of viatical/life settlement returns. Section 5 presents the viatical/life settlement index and evaluates its potential as an asset class worthy of inclusion in a typical investor's portfolio. Section 6 concludes.

II. Background

A viatical settlement is the purchase of a terminally ill individual's life insurance death benefit by an investor. Typically, the life insurance policy is sold at a discount of between 30% and 85% of face value; the investor who purchases the

death benefit assumes all future premiums and collects the face value upon the insured's death. Viatical settlements take the financial interest in the insured's death out of a family member's hands and put it into the hands of an investor who does not have any emotional, familial, or personal interest in the insured's life. Once the policy's death benefit is sold, or viaticated, the overriding interest of the investor is strictly financial. Viatical settlements are attractive to investors because the policy premium was established before the insured contracted his illness. The investor pays the premiums of someone facing normal mortality rates, while face value will be paid upon the death of someone facing the mortality rates associated with a terminal illness (Sood, Alpert, Bhattacharya, 2005). Described as "neither an insurance transaction, nor a loan compact," viatical settlements are more akin to gambling events (Trinkaus & Giacalone, 2002) where the investor bets on the insured's life expectancy and medical innovation.

While some form of viatical settlements date back to the public auctioning of policies in 18th century England (Sommer, Gustavson, &Trieschmann, 1997) (Hamwi & Rueggerm 1994), the modern origin of the viatical settlement industry stems from the AIDS epidemic of the mid to late 1980's and early 1990's. The first AIDS patients to viaticate their life insurance policies were single men "without traditional benefit concerns" (Ray, 2000). These early viators often did not have adequate liquid assets to fund expensive medical treatments that might offer some hope of survival. The death sentence once imposed by an AIDS diagnosis, along with the nature of those initially afflicted proved to be fertile soil for the growth of a new and potentially mutually beneficial industry. Viatical settlements allow individuals suffering from

AIDS to turn previously illiquid assets (their life insurance policies) into cash that they can use to fund the often prohibitively expensive medical treatments needed to increase their longevity or improve the quality of their remaining months. The viatical settlement industry has allowed policyholders to 'cash-out' of their life insurance assets at a fair market value (Doherty & Singer, 2003A). Over the years, partially in response to the dramatic developments in AIDS/HIV treatments, the focus of the viatical industry has shifted somewhat away from AIDS patients towards terminally ill patients in general (Ray, 2000) and the elderly[17]. In fact, beyond the need for costly medical treatment or general improvement in quality of life, individuals may choose to sell their life insurance death benefit for a myriad of reasons. For example, the premiums may have become too expensive or the original beneficiary has either passed away or is no longer in a position of financial need in the event of the insured's death (Doherty & Singer, 2003A).

III. Literature Review

Academic literature on the viatical and life settlement industry is sparse. With only a few exceptions, the earlier work focuses primarily on either the ethical, legal, or regulatory perspective.

The ethical and regulatory issues of the viatical settlements literature arose from the growing pains of the fledgling industry in the early 1990's. Initially, the

[17] Similar to viatical settlements, life settlements represent the purchase of an individual's life insurance death benefit; however, in the case of life settlements the seller is not a terminally ill patient. The data I use in this study consists of both life and viatical settlements.

industry operated with little state or federal regulation[18]. The imbalance of power in the relationship between the viator and the viatical settlement company soon captured the attention of policymakers. Terminally ill individuals are under extreme stress and as a result are physically and mentally vulnerable. In addition to dealing with the complex issue of their own mortality, they are potentially desperate for financial assistance to settle their debts, reduce their pain, and improve their quality of life during their remaining days (Giacalone, 2001) (Ray, 2000). The nature of their condition leaves them acutely susceptible to fraud, deceit, and malfeasance ranging from unfair pricing to foul play (Giacalone, 2001). Thus, the terminally ill have the potential to fall victim to the most morally repugnant examples of abuse and fraud. In its early stages, the viatical settlement industry was plagued with scams, ponzi schemes, and other acts of fraud committed by unscrupulous brokers and dealers (Ray, 2000). While there were certainly examples of deceitful behavior, it was the exception, not the norm; however, it did indeed bring about increased pressure to regulate the industry (Bhattacharya, Goldman & Sood 2004). The viatical settlements industry eventually came under a "patchwork" of regulations at the state and federal level, with individual states setting their own rules (Doherty & Singer, 2003B; Bhattacharya, Goldman & Sood 2004).

Although much of the literature deals with regulatory issues, one study compares the Intrinsic Economic Value (IEV) of holding the policy until death to the

[18] Several articles point out that viatical settlements do not meet the criteria established by the Securities Act of 1933 to be considered a 'security'. As a result, viatical settlements do not fall under the regulatory control of that act (Glick, 1993), (Rowland, 2003).

Life Settlement Value (LSV) of prematurely selling the death benefit of the policy[19]. It finds that the IEV ranges from 113% to 165% of the LSV (Deloitte, 2005). In all cases examined, the IEV of holding the policy until death exceeds the LSV regardless of the reinvestment choice for the life settlement proceeds (Deloitte 2005). Without examining the reason an individual chooses to viaticate their life policy, it seems clear that the most efficient, productive, and 'profitable' option would be to hold onto the life insurance policy until death. It appears that most of the inefficiency in the viatical settlement industry stems from the high fees and commissions associated with each transaction. Various life settlement company websites have documented broker's commissions ranging from 4% to 8% of face value, selling commissions ranging from 5% to 10% of gross proceeds[20], provider's origination fees of 5% of gross proceeds, and manager's and servicer's fees of approximately 5% of gross proceeds (Deloitte 2005). However, if the insured is in dire financial need and does not have any other liquid assets, viaticating his policy is a far better choice than accepting the surrender value from the insurance company. While some may cringe at the thought of taking an often steep discount from face value, in 2002 the welfare gain from viaticated life insurance policies over the policies' surrender values was over $240 million (Doherty & Singer, 2003A).

[19] The study referenced here (a joint study by Deloitte and the University of Connecticut) looks solely at life settlements, and excludes viatical settlements. Any settlement with an assumed life expectancy of less than 24 months is culled from their data set (although by the early 2000's it is entirely possible that an AIDS patient who chose to viaticate his life insurance policy could have a remaining life expectancy of greater than 24 months). While this report specifically excludes viatical settlements and therefore will differ from the findings in this paper many of their assumptions and findings can be applied to viatical settlements as well.

[20] Gross proceeds are defined as the present value of the life insurance policy's death benefit (Face Value) at a discount rate of 8% (Deloitte 2005).

It is clear that viatical and life settlements can be of great benefit to terminally ill or aging individuals. There is also much to be gained from a strong secondary market for life insurance in general. The consumer will have the option to sell his life insurance policy at market value instead of surrender value if either the policy premiums are no longer affordable or the insured experiences a significant decline in life expectancy (Doherty & Singer, 2003A). Since the market value of a policy in the secondary market ranges from 109% to 294% of surrender value (Deloitte, 2005), the consumer will place a higher value on life insurance policies and therefore increase demand in the primary life insurance market (Doherty & Singer, 2003A)[21]. In addition to the obvious benefit to insurance carriers, an increase in demand will benefit insurance agents as well. Not only will agents receive commissions from the increased policy sales, but they also potentially receive continued renewal commissions from the viaticated policies that might have otherwise been terminated/surrendered (Doherty & Singer, 2003A). Additionally, a healthy secondary market for life insurance policies might also prevent some terminally ill or elderly individuals from resorting to public assistance as it allows them to tap into a previously illiquid source of wealth (Sood, Alpert & Bhattacharya 2005)

Perhaps the largest academic foray into the viatical settlement industry is the series of papers that stem from the 2003 dissertation of Neeraj Sood titled *Cashing Out Life Insurance: An Analysis of the Viatical Settlements Market.* The studies spawned from this work are Bhattacharya, Goldman & Sood (2004), Sood,

[21] Doherty and Singer (2003A) equate the potential benefit from a strong secondary life insurance market to the benefit derived from the strong secondary market for home mortgages.

Alpert & Bhattacharya (2005) and Bhattacharya, Goldman & Sood (2009). The overall theme of this set of studies focuses on the individuals who elect to sell their insurance polices (i.e. the viator's decision); specifically, the authors examine the circumstances and decision of terminally ill AIDS/HIV patients during the mid 1990's to the early 2000's. In their research Bhattacharya, Goldman & Sood (2004), Sood, Alpert & Bhattacharya (2005) and Bhattacharya, Goldman & Sood (2009) either match up similar data used in this essay with the HIV Costs and Services Utilization Survey (HCSUS) or solely use the HCSUS. The HCSUS is a national, multi stage, survey of AIDS/HIV+ individuals who make at least one health care visit and contains a wide breadth of information (i.e. demographics, income, assets, insurance status, etc.) (Bhattacharya, Goldman & Sood 2009). While thorough, the focus on the consumer in this avenue of research is a significant difference from the aims of this paper. The collective works by Bhattacharya, Goldman, Alpert, and Sood do not explicitly examine the return and risk characteristics of the viatical/life settlement market.

To our knowledge only one study, Braun, Gatzert, and Schmeiser (2012), has empirically analyzed the risk and return characteristics of the life settlement asset class. This deficit in the literature regarding financial performance is primarily due this asset class being in its infancy and the resulting dearth of available data. Braun, Gatzert, and Schmeiser (2012) analyze monthly NAV values of 17 open-end life settlement funds from December 2003 to June 2010[22]. The authors obtain this proprietary data set from Zurich based AA-Partners, a private consulting firm that

[22] Note: not all funds present over the entire sample

specialized collecting performance data from open-end life settlements funds[23]. These data are used to create an equally weighted Life Settlement Fund Index and is subsequently compared to equities (S&P 500), government bonds (FTSE U.S. Gov. Index), Corporate Bonds (DJ U.S. Corporate Bond Index), hedge funds (HFRI Fund Weighted Composite Index), real estate (S&P/Case-Shiller Home Price Index), commodities (S&P GSCI), and finally, private equity (S&P Listed Private Equity Index).

Braun, Gatzert, and Schmeiser (2012) report a total return over the sample period of 37.30%, a mean annualized return of 4.85%, and an annualized standard deviation of 2.28% for the Life Settlement Fund Index between December 2003 and June 2010. The Life Settlement Fund Index ranked 3rd behind only government bonds and hedge funds in terms of return, but ranked 1st with the lowest volatility. In further evaluating the performance of these life settlement funds, the author report that their index ranked 1st in Sharpe ratio (0.3327), 1st in Sortino ratio (0.4580), 2nd in Calmar ratio (0.0695), and 1st in excess return/VaR (0.2889).

In addition to the attractive risk and return characteristics of their Life Settlement Fund Index, Braun, Gatzert, an Schmeiser (2012) point out that while nearly all other asset classes examined display significant correlations with each other, life settlements only show a significant negative correlation with corporate bonds[24].

Due to the nature of life settlements and the mechanics of open-end life settlement funds the high returns, low volatility, and lack of correlation described

[23] These open-end funds are purely dedicated to US. Life Settlements
[24] All other correlations are negative but statistically insignificant

above must be accepted with an enormous caveat. If questioned about the inherent risks in this assets class, we can imagine most investors would quickly identify two important risk, longevity risk and liquidity risk, however, the largest risk facing investors is valuation risk (Braun, Gatzert, and Schmeiser 2012), which might not be easily apparent. Since there is no efficient market with widely traded life settlements contracts, they cannot be marked-to-market. Therefore, each fund must rely on models to value their assets and strike their NAV. This marked-to-model process relies on extensive assumptions and in many cases is not audited by an actuarial advisor. Furthermore, model assumptions (such as the insured's life expectancy - a key determinant of return) are not updated according systematic evaluation of each settlement but rather at the discretion of the fund manager (Braun, Gatzert and Schmeiser 2012). The marked-to-model approach combined with less than rigorous updating of the model leave open the speculation that life settlement fund managers could be smoothing returns and thereby understating volatility.

In fact, according to Braun, Gatzert, and Schmeiser (2012) the performance they described could "likely be all but a mere by-product of the accounting-orientated valuation methodology" used by the life settlement funds. Additionally, the authors go on to contend that if all the funds switched to a fair value method of valuation, the life settlement asset class would be "considerably more volatile" than what their analysis has shown (Braun, Gatzert, and Schmeiser 2012).

This paper attempts to address the concerns expressed in Braun, Gatzert and Schmeiser (2012) by skipping the middleman, and examining the individual

viatical/life settlement policies before they are packaged into a fund and before a fund manager has the opportunity to influence volatility.

IV. Data and Methodology

The data I use to estimate an index for the viatical settlement market comes from the State of New York Department of Insurance filing for the years ending 1995 to 2009[25]. These filings are required of each viatical settlement company doing business in the state of New York. Each year, every viatical company must file several schedules, three of which contain the transaction level data I will be using. First, Schedule 4, "List of All Purchased Policies," is a list of each policy that the viatical settlement company has purchased and is still awaiting the death of the insured as of December 31 of each year. Schedule 4 lists the issuer, date of issue, and face value of the policy as well as the settlement amount, expenses, fees, premiums, and total cost paid by the viatical settlement company.

The Next Department of Insurance filing I use is Schedule 7, "List of Paid Viatical Settlements Where Viator's Death Occurred During the Current Year." This schedule is a list of all policies in which the viatical settlement company has collected the face value due to the death of the insured. Schedule 7 contains information about the viator (date of death, age at death, cause of death, duration from policy sale to death, and state of residence) as well as information about the viatical settlement itself

[25] While the annual filings begin in 1995, several policies purchased in 1993 and 1994 are either still 'active' in 1995 or have paid out the death benefit in 1995.

(date the policy was viaticated, assumed life expectancy, face amount viaticated, and settlement amount paid).

The last filing I use from the New York Department of Insurance is Schedule 8, "List of Viaticals Settled and Paid During the Year Where Viator's Death Has Not Occurred." It is a list of all policies the viatical settlement company has received payment on while the viator is still alive – i.e. a list of policies sold to other investors during the past year. Schedule 8 contains each viator's assumed life expectancy, state of residence, as well as the settlement's face value, settlement amount, and date viaticated.

Also, using the data in Schedule 4 of the New York Department of Insurance filings described above, I was able to estimate up-front expenses and commissions for each settlement listed in schedule 7. Up-front expenses are estimated by simply finding the average up-front expense reported on schedule 4 for each dollar of face value and applying that percentage to the schedule 7 settlements. Similarly, commissions are calculated in the same manner – the average commissions reported on schedule 4 are applied to the settlements on schedule 7. Using the data collected, I estimate up-front expenses of 5.90% and commissions of $16.47 per $1000 of face value per year.

Annual return data for fixed income and equity comparisons, portfolio construction, and market model analysis (CAPM and Fama-French factors) obtained from Ibbotson Associates and Kenneth French's website.

In many non-traditional investment markets (such as real estate, fine art, and in the case of this paper - the secondary market for life insurance policies), the largest

difficulty in trying to examine their risk – reward characteristics and market efficiency is the often inconsistent nature of observing their actual prices or returns. This issue has been circumvented in the real estate and fine art markets through the use of the hedonic regression (HR) method and the repeated sale regression (RSR) methods to create an index for each of these markets.

Real estate research has long expressed housing values as a function of time (i.e. valuation date) and a series of hedonic characteristics of the home (i.e. lot size, living area, fireplace, number of bathrooms, location such as waterfront, etc.…). The resulting hedonic model usually has the following empirical specification:

$$Log(V_{it}) = X_{it}\beta_t + \delta_t + \varepsilon_{it}. \quad (1)$$

Where V_{it} is the value of house i at time t, and X_{it} is a vector of hedonic attributes of house i at time t. In this model the hedonic characteristic coefficient vector, β, reveals the implicit price of those characteristics, and δ, the intercept at time t, represents a measure of the overall time-t price level.

A common assumption employed[26] in creating a hedonic regression index is that hedonic characteristic prices are time invariant (i.e. $\beta_t = \beta$ for all t) (Hoesli, Giaccotto and Favarger 1997). Under this assumption, implicit prices of dwelling characteristics do not change and we can interpret the time period intercepts as index levels. Fortunately, Hoesli, Giaccotto and Faverger (1997) find that this assumption does not pose a significant threat to the validity of hedonic index

[26] In real estate index creation this assumption is often necessary due to the frequent lack of large data sets (Hoesli, Giaccotto and Faverger 1997)

Two potential issues arise in the use of hedonic regression to create an index for viatical/life settlements. First, for some of the settlements, we are unable to obtain data on the insured's hedonic characteristics. Second, unlike real estate or other non-traditional assets (wine, fine art, etc…), the assets in question (life insurance policies) have a finite horizon and the payout comes not from reselling at a later date, but rather from collecting the face when the insured passes away. Therefore, we are concerned with building an index of returns on the viatical/life settlements as opposed to an index of price level paid to those selling their policies[27]. Fortunately, by using a pair of valuations over time, the repeated sale regression method can overcome these issues and construct a viatical/life settlement index.

In equation (1) X, the vector of characteristics, is held to be time invariant (in fact equation (1) only allows for a single time period's data for any given home). Consider a home that sells twice over our time horizon, first at time t and second at time t'. If we take the difference of equation (1) we get:

$$Log(V_{it'}) - Log(V_{it}) = X_{it'}\beta_{t'} - X_{it}\beta_t + D_{it'}\delta_{t'} - D_{it}\delta_t + \varepsilon_{it'} - \varepsilon_{it} \qquad (2)$$

Under the original assumptions in (1) implicit prices are time invariant and dwelling quality (characteristics) are likewise unchanged; therefore $\beta_t = \beta_{t'}$ and $X_{it} = X_{it'}$. Also note that the left hand side of (2) now equals the logarithmic, or continuously

[27] In other words, constructing an index based upon the prices paid to the viator will yield no insight into the return earn by investors. Once purchased, the policies are not sold at the 'later' price level, but rather held until the death benefit (face value) is collected.

compounded, return earned on the dwelling over the time between the initial sale and the subsequent, or second, sale. Now equation (2) can be simplified to:

$$Log\left(\frac{V_{it}}{V_{it'}}\right) = \sum_{t=2}^{T}(D_{it}\delta_t) + \varepsilon_{itt'} \quad (3)$$

Now, the left hand side is the log-price relative of house i that initially sold at time t for price V_{it} and was sold once again at time t' for $V_{it'}$, and D_{it} is a dummy variable that takes the value of -1 for the time that corresponds to the initial sale of house i, +1 for the time that corresponds to the second sale of house i, and 0 elsewhere and $\varepsilon_{itt'}$ is the disturbance term. Since the interpretation of δ_t remains the same, equation (3) allows us to create a temporal index using two valuation points.

The repeated sales regression (RSR) method described above was first proposed by Bailey, Muth, and Nourse (1963), and has been extensively used in the creation of real estate price level indices (Case & Shiller 1989, 1990; Giaccotto & Clapp 1992; Schwann 1998; Gallin 2008; Wheaton & Baranski 2009 & many others), but has also been applied to several other non-traditional, often illiquid, assets ranging from wine (Burton & Jacobson 2001) to collectables (Burton & Jacobson 1999) as well as to works of art (Goetzmann 1990, 1993; Pesando 1993; Biey & Zanola 1999; Mei & Mosses 2002; Ginsburgh, Mei & Mosses 2006).

This paper attempts to apply the repeated sale regression (RSR) methodology used in the real estate, fine art, and other non-liquid asset markets to create a quarterly index of viatical settlement (and life settlement) returns for fourth quarter 1993 through fourth quarter 2009. In order to do this, I must first

frame the settlement data I have collected in such a way that it fits with what has been done in real estate and fine art. While it is clear to see that a house or print can be purchased and later sold to create a pair of transaction and it is also clear that two identical prints sold at different times can be viewed as 'matched pair' of transactions the pairing need to perform the RSR for a viatical/life settlement is not as intuitive. In essence, what the repeated sales regression method required is two points of valuation at different time periods. For example, a house can sell in Q1 1994 for $200,000 and later sell again in Q2 of 2003 for $300,000, or one print from a publishing edition can sell in Q3 of 1999 and another (essentially identical) print from the same publishing edition can sell in Q1 of 2001. In each of these examples we have an initial sale at a certain price (value) and a subsequent 're-sale' at a different price (value) in a later period. Using the viatical settlement data collected, I will define the purchase price paid to the viator (the individual who chooses to sell his life insurance policy) as the initial sale (or initial valuation point), and the payment of face value to the purchaser of the policy upon the death of the insured as the second valuation point. In framing my data this way, I now have an initial valuation in an earlier time period with a price or value of X and subsequent (or second) valuation of Y at a later date (in this example X = the cost of purchasing the policy and Y= the face value or death benefit of the policy). I can now calculate the log-price relative for each settlement where the insured has passed away and the purchaser of the policy received the death benefit as follows: ***log(face value)-log(cost)***. Furthermore, the quarter in which the policy is originally viaticated (or sold) will correspond to the initial sales date (i.e. will have a dummy variable equal

to -1), and the quarter in which the viator (insured) dies will correspond to the subsequent, or second, sales date (i.e. will have a dummy variable equal to +1). In order to use the RSR method to calculate an index of viatical/life settlements, I am forced to make one simplifying assumption – I assume that each sale and death occur during the middle of each time period (quarter) in which they take place. A similar assumption is forced upon virtually all RSR analysis.

One major concern with the repeated sales regression method is the index's susceptibility to revisions as new data are added (i.e. properties or assets experience a second sale) (Clapp & Giaccotto 1992; Hoesli, Giaccotto & Favarger 1997; Clapham, Englund, Quigley & Redfearn 2006). Under the RSR method, each second sale is linked to a previous sale that took place during some prior period; for example a sale in period 25 could be linked to an initial sale in period 7. The linking of current to past sales within RSR necessitates re-estimating (revising) prior index values as new pairs are added to the index with each new period (Clapp & Giaccotto 1992; Hoesli, Giaccotto & Favarger 1997; Clapham, Englund, Quigley, & Redfearn 2006). While Clapham, Englund, Quigley and Redfearn (2006) find that revisions in repeat sale indices are "not inconsequential", Hoesli, Giaccotto, and Favarger (1997) both the original and revised index values are unbiased and the revised estimate is more efficient. As with all RSR indices we expect our viatical/life settlement index to be prone to revision. However, unlike housing sales, the mean time between the two transactions in our sample is only 24 months. As Hoesli, Giaccotto, and Favarger (1997) found, we expect the largest revision to occur at the end of our sample.

In light of the data used to construct a repeat sale regression index of viatical/life settlement policies, it is clear that a significant determinant of the policies return (total return and especially annualized return) is the time between the initial purchase of the policy and the death of the insured. Presumably, settlement companies expend a great deal of effort to accurately estimate the life expectancy of each viator. Typically, we assume that the viatical/life settlement companies, acting as wealth maximizing agents, will not continually make forecasts regarding life expectancies that are biased (wrong) in the same direction (Hafer 1985). As such, we should expect to find any errors in life expectancy (i.e. the difference between assumed and actual time until death) to be random and essentially cancel each other over time. When we examine the data we find that, on average, the assumed life expectancies are approximately 5 months shorter than the actual time until death. Traditionally, the test for bias in a forecast is done with the equation (4):

$$A_i = \propto + \beta P_i + \varepsilon_i. \qquad (4)$$

Where A_i is the actual time until death, P_i is the predicted (assumed) time until death, α and β are coefficients estimated via ordinary least squares (OLS), and ε_i is an i.i.d., normally distributed error term with mean of zero. An F-test of the joint hypothesis of $\alpha = 0$ and $\beta = 1$ should reveal whether or not the assumed (forecasted) life expectancy is unbiased. If the null hypothesis is rejected, the life expectancy estimates are biased.

Table I, panel 'A', presents the results of the bias test for our sample of assumed life expectancies. The regression results suggest that α is not equal to zero; it is 19.38 and is statistically significant at the 1% level. Likewise, β equals 0.66, not 1, and it also is statistically significant at the 1% level. Finally, panel 'A' of Table I shows the results of a F-test for joint significance that evaluates H0: $\alpha = 0$ and $\beta = 1$. This test confirms that the null hypothesis can be rejected. The estimates of insured's life expectancy are biased; forecasts for longer life expectancies are underestimated while those for shorter life expectancies are overestimated. In fact, given our specific data we find that assumed life expectancies below 57 months are underestimated, with the shorter life expectancies experiencing the greatest amount of underestimation. Likewise, assumed life expectancies greater than 57 months are over estimated, with the greatest overestimation coming from those with the longest assumed life expectancies. It is possible that these biases in assumed life expectancy (which plays an important role in determining the amount paid to the viator) could result in overpaying those with shorter (less than 57 months) life expectancy and underpaying those with longer life expectancies (greater than 57 months). This could lead to decreased return on lower life expectancy policies and increased returns on longer life expectancy policies.

In a similar fashion, we also test for bias in the estimates of annual return calculated from the settlement companies' initial assumptions (i.e. the annual return that would result from using the assumed life expectancies). In this test, A_i is the

actual annual return earned on settlement 'i', P_i is the estimated annual return[28] on settlement 'i'– all other parameters are as previously defined. Here, we find that the α coefficient is not equal to zero (α=.1156 with a p-value of 0.000) and the β coefficient is not equal to 1 (β=.15 with a p-value of 0.000). This is a similar pattern of bias as found above when examining assumed life expectancy. Settlements that were purchased with a small expected return (less than 13.60%) are found to 'outperform' expectations, while those settlements that were purchased with larger expected returns (greater than 13.60%) are found to 'underperform' expectations.

Finally, one additional test we can use to examine the accuracy of the settlement companies life expectancy (and the resulting annual return earned on each policy) is to calculate Theil's U inequality index using the following formula:

$$U = \frac{\sqrt{\frac{1}{n}\sum(X_i - Y_i)^2}}{\sqrt{\frac{1}{n}\sum X_i^2} + \sqrt{\frac{1}{n}\sum Y_i^2}}$$

Where X_i is the actual observation (time unit death or annual return) and Yi is the estimated forecast (assumed life expectancy or estimated annual return). This statistic varies between 0 and 1, with 0 implying a perfect forecast (i.e. X and Y are identical) and 1 implying maximum disagreement (i.e. terribly inaccurate forecast). When using actual time until death and assumed life expectancy as X and Y respectively, U = 0.50. However, when using actual annual return and estimated annual return for X and Y respectively, U = 0.98. When combined with the bias tests

[28] Estimated annual return for each settlement is calculated as follows: [1+(Face Value – Total Cost)/Total Cost]^(12/Assumed)-1. Where assumed = assumed life expectancy at the time of sale.

and regressions described above, it is clear that the settlement companies' forecasts of the time until they receive the death benefit of each policy is quite inaccurate.

The biases and inaccuracies noted above and the resulting systematic forecasting error in life expectancy (and therefore returns as well) combined with the nature of viatical/life settlements leaves us with some striking outliers. We can control for the extremes in our by using weighted least squares regression (WLS). Using weighted least squares regression (WLS) will allow us to weight each observation by the reciprocal of the difference between the actual months until death (duration) and the assumed life expectancy at the time of purchase. A significant part of the attraction to viatical settlements as an investment is the possibility (but not he guarantee) of extremely large returns in the event the viator passes away soon after viaticating the policy. Using weighted least squares regression allows us to mitigate the overall impact of a few shockingly extreme outliers on the index without excluding them all together. In order to determine our weighting vector, we follow Case and Shiller (1989) who note that homes with longer time between sales wield a larger influence on the overall index and that volatility is increased as time between sales increases. Therefore, we perform the WLS analysis using duration from sale of policy to the death of the viator as our weighting variable.

V. Empirical Results

V.1. Index Construction

Table II presents the summary statistics for our sample of viatical/life settlements. Across the entire sample, the average viator is 54 years old sells a life insurance policy with a face value of $170,435 for $103,615 and live approximately 33 months after the policy is sold; which results in a total cost to the settlement company of $136,329. The discrepancy between the amount paid to the insured and the cost to the settlement company can bound in the many layers of fees associated with viatical/life settlements. Using the averages presented above, premiums would be approximately $7,720; provider's origination fees plus manager's and servicer's fees would total about $14,938 and the remaining $10,056 in costs is the broker's upfront fee.

Table II also shows the summary stats for our sample of viatical/life settlement transactions broken down by cause of death. The majority of our settlements come from individuals suffering from AIDS (804 observations or 46.64% of the sample) followed by Other (649 observations or 37.65% of the sample), Cancer (212 observations or 12.30% of the sample), and finally Heart (59 observations or 3.42% of the sample).

The index of viatical/life settlements based upon settled policies Q4 1993 through Q4 2009 as determined by the weighted least squares (WLS) regression of equation (3) is presented in Table III and shown in Figure 1. Additionally, Figure 1 presents the S&P 500 and Russell 2000 indices over the same time period (Q4 1993 – Q4 2009). Over the entire index we see an annualized return of 7.60% and an annual standard deviation of 34.49% for viatical/life settlements. A $1,000 investment in these settlements made in the 4th quarter of 1993 would grow to

approximately $3,261 at the end of the 4th quarter 2009 compared to a $1,000 investment in the S&P 500 and long term corporate debt would only grow to approximately $2,400 and $3,000 respectively over the same time period. In other words, over the time period examined in this paper, an investment into viatical/life settlements would end up approximately 36% larger than an equal investment in the stock market[29] and 9% larger than an equal investment in long term corporate debt. Figure 2 illustrates the value of this hypothetical $1,000 investment over our entire sample beginning in Q4 1993. Figure 3 provides a comparison of each investment at 3 year, 6 years, 9 years, 12 years, and over the entire sample. Despite being out performed in the first 12 years of the sample, we can see that viatical settlements not only significantly out perform other assets over the entire sample, they also do not display the losses in several time periods that we see in the S&P 500.

V.2. Market Model Analysis

While establishing the risk and return characteristics of viatical settlements on their own is valuable, investors will be most concerned with how much risk this new investment will add to existing, well diversified, portfolios. The examination of the systematic risk component of our new Viatical Settlement Index will be based upon

[29] Since our sample ends in the 4th quarter of 2009, the return on the S&P 500 are still significantly impacted by the massive economic downturn of 2008 – 2009. The difference in the final value of $1,000 invested in Q4 1993 highlight the lack of correlation with traditional investments and the lack of systematic risk exposure that make viatical/life settlements a potentially attractive alternative asset.

several traditional market models, specifically, the Capital Asset Pricing Model (CAPM) and the Fama and French Three Factor Model.

First, we will adapt what has been the most widely used tool to evaluate systematic risk, the CAPM, to compute a Beta for our viatical settlements. Equation (5) below shows the regression used to calculate our viatical settlement Beta.

$$R_i - R_f = \alpha_i + \beta_i\left(R_m - R_f\right) + \epsilon \ . \qquad (5)$$

Where R_i is the quarterly return on the i^{th} viatical settlement, R_f is the quarterly risk free rate, and R_m is the quarterly return on the S&P 500. While modern improvements and alternative models may be more consistent and accurate, the traditional CAPM is still the de facto standard when examining the systematic risk within an asset, and has been widely adopted by researchers examining the systematic risk of other 'non-traditional' asset classes (Pesando 1993; Clapp and Giaccotto 1995; Mei and Moses 2002; and Sanning, Shaffer, and Sharratt 2006). Table IV presents the results of the ordinary least squares regression shown in equation (5). We can see that neither the α coefficient (representing abnormal excess return) nor the β coefficient (representing systematic risk) are statistically different from zero (with p-values of 0.75 and 0.44 respectively). Furthermore, with an R-squared of 0.01 we can see that the traditional single factor market model does a very poor job of explaining the return on the Viatical Settlement Index. Likewise, viatical settlement returns are not significantly impacted by market risk.

We next examine the Fama and French three factor model. Since the late 1970's the validity of the traditional, Sharpe-Lintner, CAPM has been called into

question.[30] After observing small stocks outperforming large stocks and value stocks out performing growth stocks, Fama and French (1993, 1996) improve upon the CAPM by developing the three-factor model. Their model begins with the market risk premium used in the traditional one factor model, but goes on to add a small minus big (SMB) factor and a high minus low (HML) factor to capture size risk and value risk. The three-factor model developed by Eugene Fama and Kenneth French is presented in equation (6) below:

$$R_{it} - R_{ft} = \alpha_i + \beta_{iM}\left(R_{Mt} - R_{ft}\right) + \beta_{is}(SMB_t) + \beta_{ih}(HML_t) + \epsilon_{it} \ . \qquad (6)$$

SMB_t is the small minus big factor for time 't'; it captures size risk and is the return on portfolios made up of small stocks minus the return on portfolios made up of large stocks. HML_t is the high minus low factor for time 't'; it is made up of the return on portfolios made up of high Book/Market stocks minus the return on portfolios of low Book/Market stocks and captures value risk. Several studies, originating with Fama and French (1992) have employed the size factor (SMB) and value factor (HML) to capture the anomaly that small firms and high book to market firms tend to outperform the market. Under the assumption of efficient and rational markets, these anomalies must originate with some previously unidentified risk that is not captured in the one factor model (CAPM). While becoming common in the examination of equity returns and other traditional asset classes, using the Fama-French three-factor model to evaluate non-traditional assets is much more rare, with Sanning, Shaffer, and Sharratt (2006) serving as an exception. We use the Fama-French three facor model to examine any systematic risk component within

[30] See Basu (1977), Banz (1981), Stattman (1980), Rosenberg, Reid and Lanstein (1985), and Bhandari (1988)

the Viatical Settlement Index that might be captured in the size and value factors. Table IV also presents the ordinary least squares regression analysis of the Fama-French three factor model. Unsurprisingly, while this regression of the Fama-French three-factor model does yield an R^2 that is more than double that of the single factor regression, none of the coefficients for market, size, or value are statistically significant.

After examining viatical/life settlements in the context of market model analysis based upon the traditional CAPM and the Fama-French three-factor model, we find insignificant risk factor betas indicating that there is very little systematic risk within these settlements. This discovery leads directly to the following question: how could viatical/life settlements fit in to the existing world of investment assets?

V.3. Viatical/Life Settlements as an Asset Class

While the potential returns on viatical/life settlements are attractive (7.6% annual return vs. 5.56% for the S&P 500), the standalone risk is potentially frightening (34.49% annual variance vs. 17.27% for the S&P 500). However, in light of the market model analysis presented above, viatical/life settlements should still be enticing as part of a diverse portfolio of mostly 'traditional' assets, provided the lack of systematic risk leads to a reduction in overall portfolio risk. The first step in revealing the roll viatical/life settlements should play in a portfolio is determining their correlation with the more traditional asset class we are accustomed to including in a portfolio. Table V, Panel 'A' presents the correlation matrix for viatical settlements, the S&P 500 and long term corporate bond returns. We can see that

both measures of traditional assets posses a very low degree of correlation with viatical settlements, 0.094 and 0.004 for the S&P and long term corporate debt, respectively. Given the correlations presented in table V, it seems clear that there should be a significant role for viatical/life settlements in most investors' portfolios.

Panel 'B' of Table V presents the minimum variance portfolios for a mix of large cap equity, viatical/life settlements and long term corporate debt. Clearly, despite the seemingly high stand-alone risk of viatical/life settlements, a diversified investor could still benefit from adding them to their portfolio. For example, when examining the addition of viatical/life settlements for an investor who invests in a mix of equity (S&P 500) and debt (long-term corporate bonds) the minimum variance portfolio consists of 24.09% equity, 71.48% long-term debt, and 4.43% viatical settlements. This results in an expected annual portfolio return of 6.62% with a standard deviation of 8.20%.

Panel 'C' of table V presents the Sharpe optimal portfolio for an investor across equities (S&P 500), debt (long term corporate debt), and viatical/life settlements using both the T-bill and the t-bond as the risk free rate. Regardless of our choice of risk free rate, we can see that despite the large stand-alone risk, viatical/life settlements should still play a prominent role in portfolio diversification. When using the short term T-bill the optimal portfolio includes a 6.71% allocation to viatical settlements; likewise, using the longer term t-bond the optimal portfolio includes a 17.04% allocation.

V.4. Portfolio Diversification

In order to more fully explore the diversification potential initially described in section 5.3 above, we now construct five different investment portfolios designed to represent the risk aversion and portfolio asset allocations of typical investors. In doing this, we build upon the disconnect between mutual fund theory and popular (i.e. real world) investment counsel described by Canner, Mankiw, and Weil (1997). In contrast to theory, Canner, Mankiw, and Weil (1997) find that most professional asset allocation advice groups investors into specific risk categories and defines a separate asset allocation for each category. Specifically, Canner, et al. identify three risk categories used to separate investors: Conservative, Moderate, and Aggressive. We, however, will modify this slightly by using five risk level based portfolio strategies: Conservative, Moderately Conservative, Balanced, Moderately Aggressive, and Aggressive. We can now examine the effect of including viatical/life settlements into the typical portfolios of the five categories of typical investors identified above. Table VI presents the asset allocation for each investor risk category with panel 'A' representing portfolios without viatical/life settlements and panel 'B' representing the portfolios with a 20% stake in viatical/life settlements. As a starting point, each of the panel 'A' portfolios allocate between Fixed Income (the 3 month CD rate), Bonds (AAA corporate rate), Blue Chips (S&P 500), Mid Cap (S&P 400), and small cap (Russell 1000). In the case of portfolios in panel 'B', the 20% portion allocated to viatical/life settlements in each portfolio is proportionally drawn from each asset class in the original (panel 'A') allocation of each portfolio. As illustrated in Table VI, the more risk adverse investors prefer lower risk assets,

but as risk aversion decreases (i.e. a move towards more aggressive investing) the portfolios gradually include a larger portion of more volatile assets. Figures 4 and 5 show the performance of each portfolio over our examination period. Clearly we can see that an investor's appetite for risk does indeed impact portfolio performance. In both the 'without' portfolios (figure 4) and the 'with' portfolios (figure 5) we see that in boom-periods the riskier portfolios significantly outperform the less risk portfolios, but that this trend is mitigated (and actually eliminated) during periods of downturn. We also find evidence that during economic downturns (or crisis) all portfolios appear to find a relatively common floor in returns. In fact, the economic crisis of 2008 and 2009 drove down the returns on the aggressive and moderately aggressive portfolios to such an extent that over the entire sample, the balanced portfolio actually out performed the two riskier portfolios. When we look for the impact of adding viatical/life settlements, we find similar patterns, but at higher final return levels and some evidence less volatility.

Table VII, panels 'A' and 'B', present the portfolio statistics for each hypothetical investment portfolio, with panel 'B' representing the portfolios that include a 20% allocation to viatical/life settlements. In both panels, we can see, without much surprise, that as risk aversion decreases (i.e. investors become more aggressive), portfolio return and volatility increases (up until the financial crisis of 2008 – 2009). However, what is worth noting is the impact of viatical/life settlements demonstrated in panel 'B'. In each portfolio, we find an increased return when viatical/life settlements are included, and for least risk adverse investors we see a

decrease in portfolio volatility. In fact, for the most aggressive investors, an allocation of 20% to viatical/life settlements will result in an increase in mean annual return of 0.19% and a decrease in annual portfolio standard deviation of 1.36% while moderately aggressive investors will see an increase in return of 0.12% and an decrease in standard deviation of 0.31% per year. It should be noted here that while investors in the more risk adverse spectrum face an increase in volatility along with their increase in returns, it is highly likely that a 20% allocation in viatical/life settlements is less than ideal for these investors. It is possible, if not probable, that the inclusion of viatical/life settlement would indeed prove beneficial at some lower allocation level.

The benefit of viatical/life settlements can be even more clearly shown in panels 'C' and 'D' of table VII, which examine portfolio performance during the economic crisis period of 2008Q1 through 2009Q4. In all portfolios, including a 20% allocation to viatical/life settlements significantly increases return by a minimum of 6.36% to a maximum of 9.10% per year resulting in positive annualized returns for 2 of the 5 portfolios (vs. all 5 portfolios having negative returns without viatical settlements). However, all but the most aggressive portfolios do experience higher standard deviations (although the increase diminishes as risk tolerance increases).

Finally, we turn back to the CAPM in order to evaluate the ten investment portfolios created above. Table VIII, panel 'A' presents the results of the OLS regression of the CAPM for each portfolio over our examination period as shown in equation (7) below.

$$R_p - R_f = \alpha_p + \beta_p(R_m - R_f) + \epsilon \ . \quad (7)$$

Where R_p is the return on the portfolio, α_p is the portfolio alpha, β_p is the portfolio beta, R_m is the market return, and R_f is the risk free rate. In both sets of portfolios we find all α coefficients to be insignificant. However, all β coefficients are significant at the 1% level and for each risk level portfolios that include a viatical/life settlement allocation display lower betas than their counterparts without these settlements. In fact, we find that across all risk levels, the betas for the portfolios with viatical settlements have betas that are approximately 10% lower than the portfolios without viatical/life settlements.

As illustrated in Table VII, panels 'C' and 'D', viatical/life settlements are even more attractive during periods of economic crisis/downturn. With Panels 'C' and 'D' of Table VII in mind, we perform and additional CAPM regression, this time including a dummy variable for the economic crisis/downturn from 2008Q1 to 2009Q4 as shown in equation (8) below and reported in Table VIII, panel 'B'.

$$R_p - R_f = \alpha_p + \beta_p(R_m - R_f) + D_{fc}\left(\alpha_p^{fc} + \beta_p^{fc}(R_m - R_f)\right) + \epsilon \ . \quad (8)$$

Where D_{fc} is a dummy variable taking the value of 1 during time of financial crisis (2008Q1 to 2009Q4) and the value of 0 otherwise. We can see that the non-crisis betas for the portfolios that include viatical settlements are all significantly lower than the portfolios that do not include viatical settlements. Additionally, for the less risk adverse investors (specifically, moderately aggressive and aggressive investors)

we find that the portfolios without viatical/life settlements display positive, statistically significant, crisis-betas while the portfolio betas with viatical/life settlements are not statically different from zero.

VI. Conclusion

In this paper, we have presented and analyzed the risk and return characteristics of viatical/life settlements (life insurance policies purchased on the secondary market). First, using the repeat sales method initially developed for analyzing real estate markets, we construct an index of viatical/life settlement returns from 1993:Q4 to 2009:Q4. Second, in analyzing this index, we find that while they do display the potential to earn highly attractive returns (besting the U.S. equity markets by nearly 2.04% per year) they also contain significant stand alone risk represented by a standard deviation that is 2.0x that of the S&P 500. The volatility revealed in this analysis differs significantly from that displayed in closed end funds made up of these settlements. However, it does support the notion that the low volatility exhibited by such closed end funds could merely be a result of the in house, "accounting orientated valuation system" used by these close ends funds (Braun, Gatzert and Schmeiser 2012).

We go on to find that viatical/life settlements have low correlations with traditional investment assets (equities, corporate bonds, etc.); furthermore, using CAPM analysis, we show that these settlements contain virtually none of the systematic risk found in those traditional assets.

Despite the high stand-alone risk of viatical settlements, the attractive returns, lack of positive correlation, and absence of systematic risk prompted us to analyze the significant diversification benefits that can be achieved by including viatical/life settlements in 'traditional' investment portfolios. We find that less risk adverse investors will significantly benefit from including viatical/life settlements in their portfolio by increasing returns and decreasing volatility[31]. In times of economic crisis or downturn, all investors see higher returns (conservative, moderately conservative, and balanced portfolios actually see positive returns unlike their counterparts without viatical settlements), however, this comes at the expense of a slight increase in volatility. We also find that portfolios with viatical/life settlements achieve statistically significantly lower betas than portfolios made entirely of 'traditional' assets for all investors. Finally, we show that in times of economic crisis less risk adverse investors that include an allocation to viatical/life settlements show significantly less exposure to systematic risk when compared to similar investors that do not include such an allocation.

Others have identified the benefit to consumers and insurance markets derived from a healthy secondary market for life insurance policies. This paper clearly identifies that there is a tremendous benefit to including viatical/life settlements in a well-diversified portfolio for most investors.

[31] As noted earlier in this paper, it is possible (if not probable) that other investors (i.e. balanced, moderately conservative, and conservative) could benefit by including a smaller allocation of viatical settlements than what we have used in our analysis.

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Tables and Figures

Table I

Tests for Biases

This table presents the results of the traditional test for biased forecasts – in our case estimated life expectancy and estimated annual return. We perform an OLS regression of the following equation: $A_i = \propto + \beta P_i + \varepsilon_t$. Where A_i is the actual time until death for viator 'i' or the annual return earned on policy 'i', P_i is the predicted (or assumed) life expectancy determined by the settlement company at the time the policy was viaticated or the estimated annual return calculated from the settlement company's original estimates, α and β are OLS determined coefficients, and ε is an i.i.d., normally distributed error term with a mean of zero. A F-test is done to evaluate the null hypothesis, H0: α=0 and β=1; if this null hypothesis is rejected the estimated life expectancies or estimated annual returns are biased.

Panel A: Life Expectancy Bias Test

Coefficient:	**Constant**	**Assumed L. E.**	**R-Squared**
Estimate	19.38	0.66	0.06
t-Stat	13.01	10.91	
p-Value	0.00	0.00	
F-Statistic	*119.09*		
F-Stat p-Value	*0.00*		

Panel B: Estimated Annual Return Bias Test

Coefficient:	**Constant**	**Expected Return**	**R-Squared**
Estimate	1.12	0.15	0.05
t-Stat	120.00	9.99	
p-Value	0.00	0.00	
F-Statistic	*99.93*		
F-Stat p-Value	*0.00*		

Table II

Summary Statistics of Viatical/Life Settlement Policies Where Death of the Insured has Occurred

Data were obtained from the New York State Department of Financial Services (Insurance Division); specifically, schedule 4. All figures represent averages calculated from all polices listed in schedule 4. All dollar amounts are in actual dollars, age is in years, and life expectancies are in months. In addition to the entire sample, the summary statistics for each major cause of death are also presented in table II.

Panel A:

	Entire Sample	**AIDS**	**Heart**	**Cancer**	**Other**
Face Value	170,435	93,522	192,860	344,636	206,385
Amount Paid to Viator	103,615	61,905	99,073	212,684	112,833
Total Cost to Settlement Co.	136,329	79,698	135,654	276,005	153,492
Age of Viator	54	50	60	59	56
Assumed Life Expectancy	20.54	17.67	28.92	18.53	24.27
Duration until Death	33.04	30.58	34.69	26.18	38.19
Total Return	22.33%	16.00%	35.19%	22.21%	29.61%
Expected Annualized Return	13.57%	11.96%	13.72%	14.67%	14.81%
Actual Annualized Return	7.59%	6.00%	10.99%	9.63%	8.49%
Count	1724	804	59	212	649

Panel B:

	Pre 1996	**1996 - 2000**	**2001 - 2005**	**Post 2005**
Face Value	79,113	89,407	190,906	574,609
Amount Paid to Viator	55,422	61,202	99,735	251,169
Total Cost to Settlement Co.	74,144	76,549	139,914	400,674
Age of Viator	58	47	54	63
Assumed Life Expectancy	13.99	17.28	25.46	31.12
Duration until Death	10.06	16.86	48.47	86.91
Total Return	14.53%	15.53%	31.08%	36.05%
Expected Annualized Return	11.82%	10.50%	15.39%	16.22%
Actual Annualized Return	17.57%	10.82%	6.93%	4.34%
Count	441	516	594	173

Table III

Viatical/Life Settlement Return Index : Q4 1993 – Q4 2009

Quarterly index of viatical/life settlements for the fourth quarter 1993 through the fourth quarter 2009, calculated via the repeated sale regression method (RSR) using the following equation: $Log\left(\frac{V_{it}}{V_{it'}}\right) = \sum_{t=2}^{T}(D_{it}\times\delta_t) + \varepsilon_{itt'}$. Where $v_{it'}$ is the face value of the policy, v_{it} is the cost to the settlement company, D_{it} is a dummy variables that take the value of -1 in the quarter the policy is purchased from the insured, +1 in the quarter the insured passes away, and zero elsewhere.

Quarter	δ = log index	SE(δ)	t-stat	p-value	δ - δ$_{-1}$	Exp(δ)
1993:Q4	0	--	--	--		***1.000***
1994:Q1	0.038	0.035	1.100	0.272	0.038	***1.039***
1994:Q2	0.073	0.035	2.094	0.036	0.034	***1.075***
1994:Q3	0.062	0.032	1.917	0.055	-0.011	***1.064***
1994:Q4	0.106	0.038	2.797	0.005	0.044	***1.111***
1995:Q1	0.123	0.028	4.466	0.000	0.017	***1.131***
1995:Q2	0.114	0.025	4.479	0.000	-0.009	***1.120***
1995:Q3	0.149	0.027	5.562	0.000	0.035	***1.161***
1995:Q4	0.178	0.028	6.333	0.000	0.029	***1.195***
1996:Q1	0.160	0.032	4.986	0.000	-0.018	***1.174***
1996:Q2	0.203	0.034	5.995	0.000	0.042	***1.225***
1996:Q3	0.179	0.036	5.003	0.000	-0.024	***1.196***
1996:Q4	0.205	0.039	5.217	0.000	0.026	***1.227***
1997:Q1	0.167	0.033	5.007	0.000	-0.037	***1.182***
1997:Q2	0.186	0.034	5.403	0.000	0.019	***1.204***
1997:Q3	0.215	0.034	6.320	0.000	0.029	***1.240***
1997:Q4	0.248	0.036	6.817	0.000	0.033	***1.282***
1998:Q1	0.058	0.055	1.040	0.299	-0.191	***1.059***
1998:Q2	0.129	0.063	2.062	0.039	0.072	***1.138***
1998:Q3	-0.133	0.048	-2.763	0.006	-0.262	***0.876***
1998:Q4	0.048	0.056	0.866	0.386	0.181	***1.050***
1999:Q1	0.154	0.061	2.536	0.011	0.105	***1.166***
1999:Q2	0.047	0.053	0.893	0.372	-0.106	***1.048***
1999:Q3	0.113	0.051	2.204	0.028	0.066	***1.120***
1999:Q4	0.186	0.050	3.747	0.000	0.072	***1.204***
2000:Q1	0.248	0.048	5.148	0.000	0.062	***1.282***
2000:Q2	0.204	0.049	4.139	0.000	-0.044	***1.227***
2000:Q3	0.400	0.048	8.354	0.000	0.195	***1.492***
2000:Q4	0.285	0.053	5.349	0.000	-0.115	***1.330***
2001:Q1	0.359	0.039	9.192	0.000	0.074	***1.432***
2001:Q2	0.403	0.046	8.740	0.000	0.045	***1.497***
2001:Q3	0.502	0.038	13.074	0.000	0.099	***1.653***
2001:Q4	0.362	0.044	8.276	0.000	-0.140	***1.437***
2002:Q1	0.333	0.057	5.795	0.000	-0.029	***1.395***
2002:Q2	0.356	0.068	5.255	0.000	0.023	***1.428***
2002:Q3	0.531	0.060	8.914	0.000	0.175	***1.700***
2002:Q4	0.517	0.081	6.397	0.000	-0.014	***1.677***
2003:Q1	0.559	0.074	7.571	0.000	0.042	***1.750***
2003:Q2	0.165	0.082	2.016	0.044	-0.395	***1.179***
2003:Q3	0.010	0.081	0.129	0.897	-0.154	***1.011***
2003:Q4	0.510	0.090	5.655	0.000	0.500	***1.666***
2004:Q1	-0.123	0.095	-1.296	0.195	-0.634	***0.884***
2004:Q2	-0.051	0.098	-0.517	0.606	0.073	***0.950***
2004:Q3	-0.113	0.081	-1.397	0.162	-0.063	***0.893***
2004:Q4	0.400	0.125	3.194	0.001	0.513	***1.491***
2005:Q1	0.567	0.055	10.289	0.000	0.167	***1.762***
2005:Q2	0.553	0.059	9.407	0.000	-0.014	***1.739***
2005:Q3	0.624	0.057	10.888	0.000	0.071	***1.867***
2005:Q4	0.767	0.056	13.777	0.000	0.142	***2.152***
2006:Q1	0.694	0.086	8.049	0.000	-0.073	***2.001***
2006:Q2	0.494	0.093	5.319	0.000	-0.200	***1.638***
2006:Q3	0.715	0.110	6.472	0.000	0.221	***2.044***
2006:Q4	0.513	0.116	4.422	0.000	-0.202	***1.670***
2007:Q1	0.704	0.103	6.828	0.000	0.191	***2.022***
2007:Q2	0.611	0.079	7.737	0.000	-0.094	***1.841***
2007:Q3	0.612	0.102	6.025	0.000	0.002	***1.845***
2007:Q4	0.841	0.092	9.088	0.000	0.228	***2.318***
2008:Q1	0.742	0.114	6.524	0.000	-0.098	***2.101***
2008:Q2	0.956	0.086	11.107	0.000	0.213	***2.601***
2008:Q3	0.966	0.094	10.331	0.000	0.011	***2.628***
2008:Q4	0.883	0.119	7.439	0.000	-0.083	***2.418***
2009:Q1	0.703	0.098	7.196	0.000	-0.180	***2.019***
2009:Q2	1.013	0.118	8.607	0.000	0.311	***2.755***
2009:Q3	1.014	0.134	7.550	0.000	0.001	***2.758***
2009:Q4	1.182	0.170	6.947	0.000	0.168	***3.261***
R-Squared	**0.177**					

Figure 1

Viatical Settlement Index 1993:Q4 through 2009:Q4 compared to S&P 500 and Long Term Corporate Debt

Figure 1 illustrates the growth of $1.00 invested in the viatical settlement index, the S&P 500, and long term corporate bonds from 1993Q4 to 2009Q4

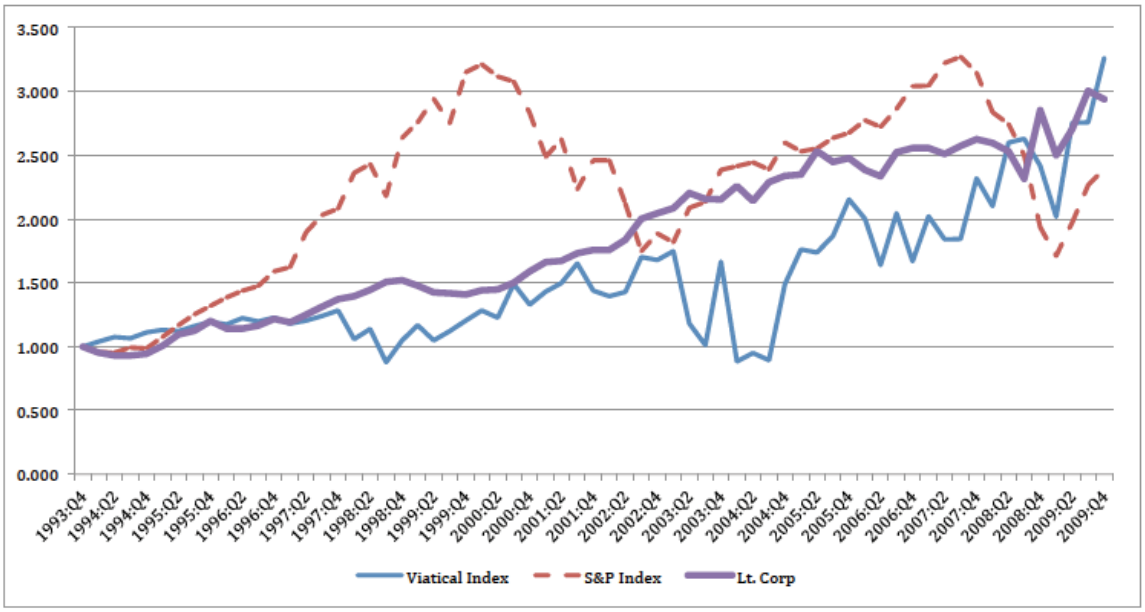

Figure 2

Comparison of viatical settlements, S&P 500, and Long Term Debt

Figure 2 illustrates the value of $1,000 invested in the viatical settlement index, the S&P500, and long term corporate debt over investment horizons of 3, 6, 9, 12 and 15 years as well as over the entire sample.

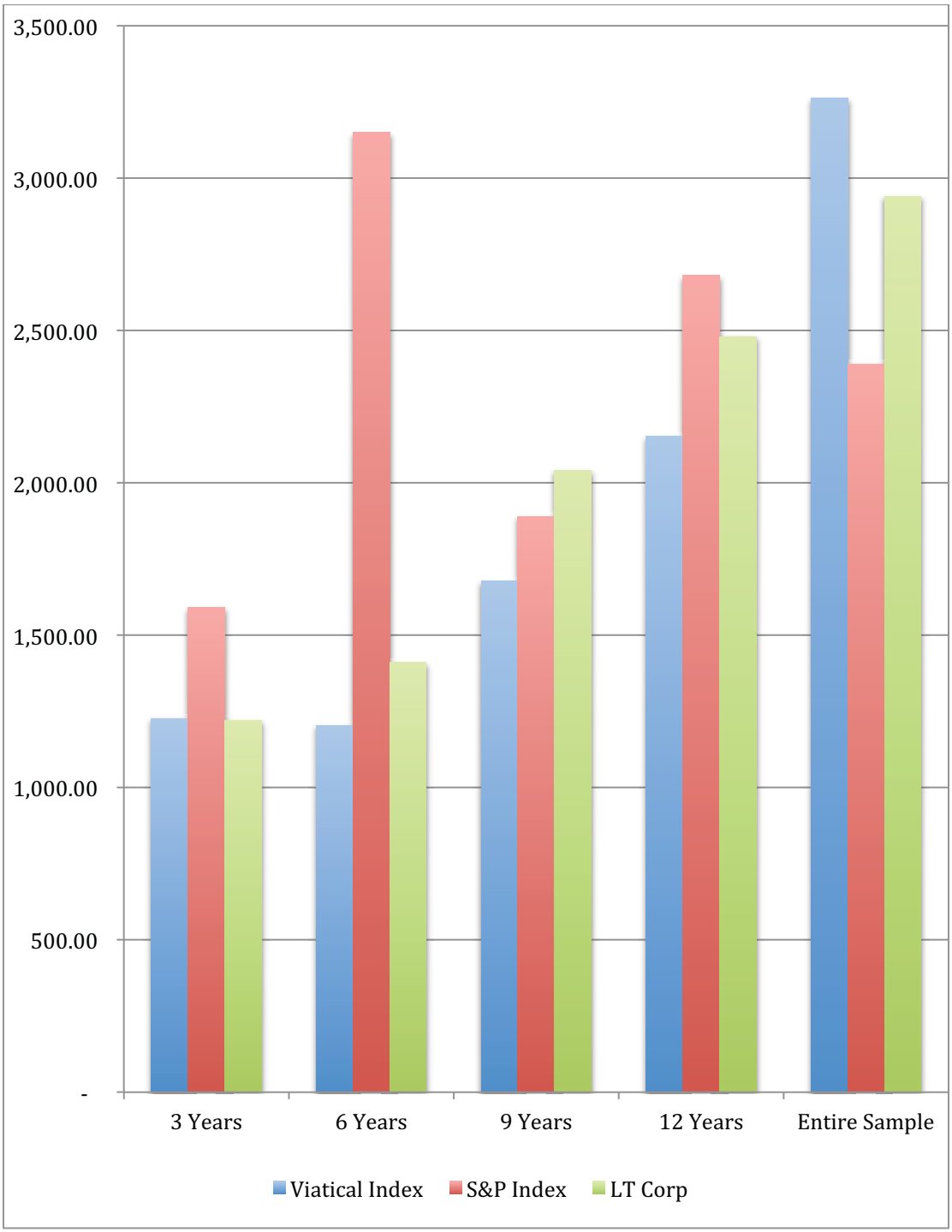

Table IV

CAPM and Fama-French 3 Factor Market Models

This table evaluates the repeat sale regression method viatical/life settlement index using the de rigueur standard market model, CAPM, as well as the Fama-French 3 Factor model. For the capital asset pricing model we evaluate the following equation:

$R_t - R_f = \alpha_i + \beta_i(R_m - R_f) + \epsilon$.

Where Ri – Rf is the risk premium earned on viatical/life settlement index at time 't', Rm – Rf is the market risk premium, and ε is the error term. For the Fama-French 3 Factor model, we evaluate the following formula:

$$R_t - R_{ft} = \alpha_i + \beta_{iM}(R_{Mt} - R_{ft}) + \beta_{is}(SMB_t) + \beta_{ih}(HML_t) + \epsilon_{it}$$

Where Ri – Rf is the risk premium on the viatical/life settlement index at time 't', Rm – Rf is the market risk premium, SMB is the size risk factor, HML is the book value risk factor, and ε is the error term. Ordinary least squares was used for each regression.

Coefficient:	**Constant**	**RPM**	**SMB**	**HML**	**R-square**
Estimate:	0.699	0.191	--	--	0.009
t-Stat:	0.316	0.781	--	--	
p-value:	0.753	0.438	--	--	
Estimate:	0.917	0.283	-0.350	-0.079	0.022
t-Stat:	0.408	1.023	-0.791	-0.296	
p-value:	0.685	0.311	0.432	0.768	

Table V

Correlations and Portfolio Weights

Panel presents the correlations between the returns on viatical/life settlements and the U.S. stock market (S&P 500) and U.S. corporate debt. Panel 'B' presents the minimum variance portfolio constructed of viatical/life settlements, U.S. stocks, and U.S. corporate debt. Finally, Panel C presents the Sharpe optimal portfolios constructed of viatical/life settlements, U.S. stocks, and U.S. corporate debt using both the short term T-bill and the longer term T-bond as the risk free rate.

Panel A: Correlations

	Viatical	S&P 500	LT Corp
Viatical	1.000		
S&P 500	0.094	1.000	
LT Corp	0.004	-0.058	1.000

Panel B: Minimum Variance Portfolios

	S&P 500	LT. Corp	Viaticals
Weight	24.09%	71.48%	4.43%
Return	5.56%	6.92%	7.60%
St. Dev	17.27%	9.86%	34.49%
Portfolio Return	6.62%		
Port St. Dev	8.20%		

Panel C: Optimal Portfolios

Risk Free Rate: T-bill = 1.80%

	S&P 500	LT. Corp	Viaticals
Weight	18.06%	75.93%	6.01%
Return	5.56%	6.92%	7.60%
St. Dev	17.27%	9.86%	34.49%
Portfolio Return	6.71%		
Port St. Dev	8.29%		

Risk Free Rate: T-bond = 6.49%

	S&P 500	LT. Corp	Viaticals
Weight	0.00%	82.96%	17.04%
Return	5.56%	6.92%	7.60%
St. Dev	17.27%	9.86%	34.49%
Portfolio Return	7.03%		
Port St. Dev	10.09%		

Table VI
Sample Asset Allocation According to Various Investment Philosophies

This table presents representative asset allocation for portfolios across five risk aversion levels (or investment philosophies). In order of risk tolerance the portfolios are, Conservative, Moderately Conservative, Balanced, Moderately Aggressive, and Aggressive. These portfolios consist of varying weights of Fixed Income (certificates of deposit), Bonds (U.S. Long Term Corporate), Blue Chips (S&P 500), Mid Cap (S&P 400), and Small Cap (Russell 1000). Panel 'A' presents the asset allocation for the five portfolios without an allocation to viatical/life settlement. Panel 'B' includes a 20% allocation to viatical/life settlements for each portfolio (all other allocations were reduced proportionally).

Panel A: Portfolios Without Viatical Settlements

	Cons.	Moderately Conservative	Balanced	Moderately Aggressive	Aggressive
Fixed Income	40.0%	25.0%	0.0%	0.0%	0.0%
Bonds	40.0%	35.0%	40.0%	20.0%	0.0%
Blue Chips	20.0%	20.0%	30.0%	40.0%	40.0%
Mid Caps	0.0%	10.0%	15.0%	20.0%	30.0%
Small Caps	0.0%	10.0%	15.0%	20.0%	30.0%

Panel B: Portfolios With Viatical Settlements

	Conservative	Moderately Conservative	Balanced	Moderately Aggressive	Aggressive
Fixed Income	32.0%	20.0%	0.0%	0.0%	0.0%
Bonds	32.0%	28.0%	32.0%	16.0%	0.0%
Blue Chips	16.0%	16.0%	24.0%	32.0%	32.0%
Mid Caps	0.0%	8.0%	12.0%	16.0%	24.0%
Small Caps	0.0%	8.0%	12.0%	16.0%	24.0%
Viaticals	20.0%	20.0%	20.0%	20.0%	20.0%

Figures 3&4:

Investment Portfolio Performance 1993:Q4 through 2009:Q4

Figures 3 & 4 illustrates the growth of $1.00 invested in each representative portfolio beginning in 1993Q4 through 2009Q4

Figure 3: Investment Portfolios without viatical settlements

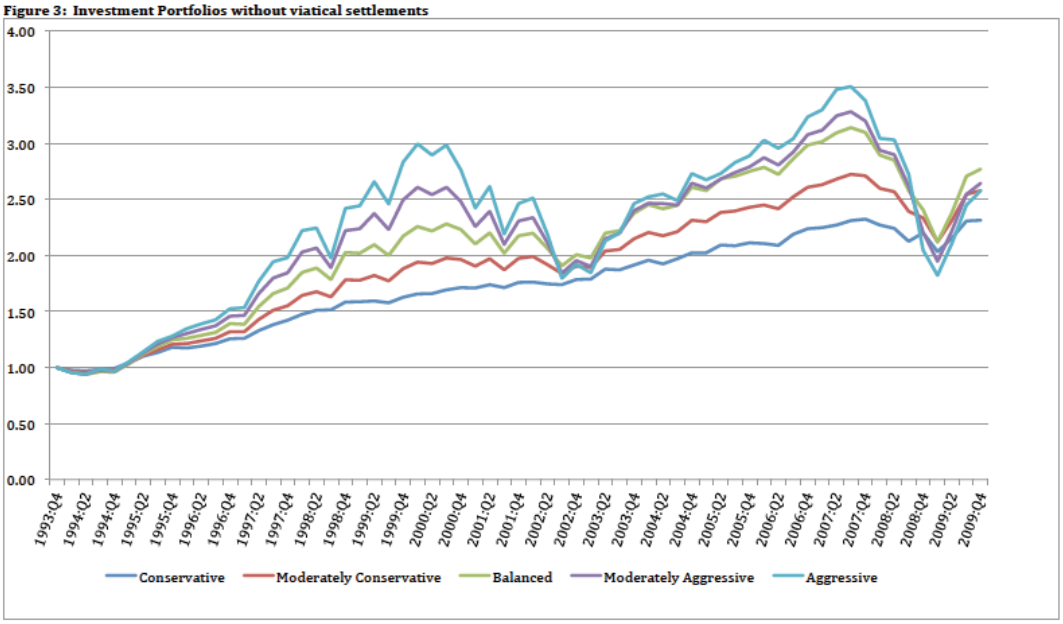

Figure 4: Investment Portfolios with viatical settlements

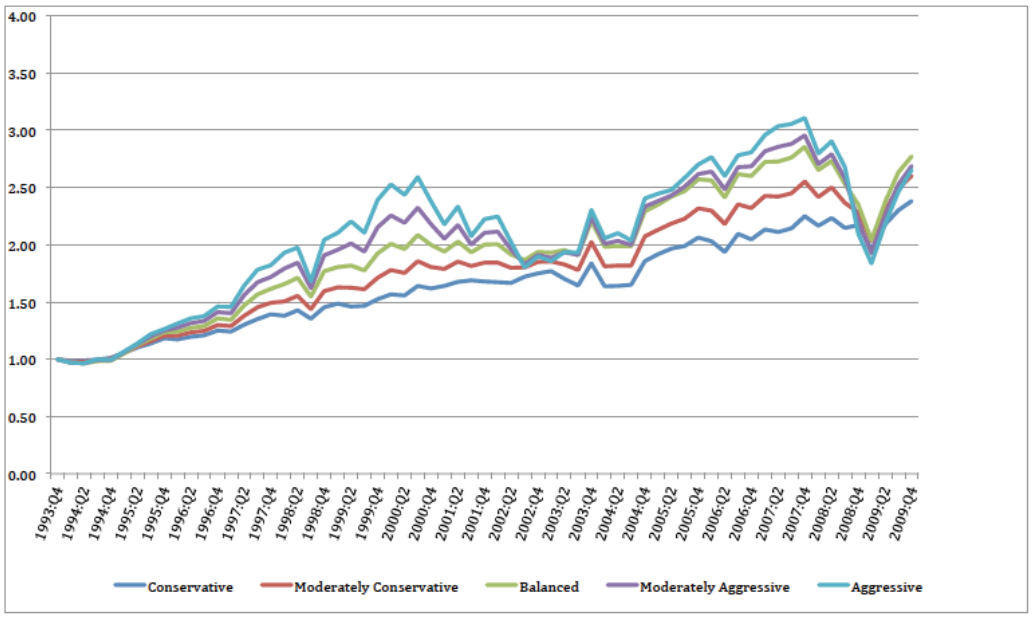

Table VII

Investment Portfolio Statistics

This table presents the risk and return statistics for the five hypothetical portfolios (constructed according to investment philosophy/risk tolerance). Panel 'A' presents the portfolios without the inclusion of viatical/life settlements. Panel 'B' presents the portfolios with viatical settlements (a 20% allocation). Panels C and D present the portfolio characteristics during the 2008 - 2009 economic downturn (recession) for portfolios without and with viatical settlements respectively.

Panel A: Portfolios Without Viatical Settlements

	Cons.	Moderately Cons.	Balanced	Moderately Aggressive	Aggressive
Total return over period	131.15%	157.82%	176.97%	164.32%	157.82%
Mean return (QTR)	1.32%	1.49%	1.60%	1.53%	1.49%
Annualized	5.38%	6.10%	6.57%	6.26%	6.10%
Median return (QTR)	1.29%	1.55%	1.86%	2.45%	2.47%
Annualized	5.26%	6.33%	7.67%	10.19%	10.26%
Standard Deviation	2.57%	3.86%	5.56%	7.08%	8.88%
Annualized	5.14%	7.73%	11.12%	14.16%	17.76%
Maximum (QTR)	7.03%	9.99%	13.64%	17.61%	22.36%
Minimum (QTR)	-7.68%	-9.08%	-12.07%	-15.82%	-24.92%
Skewness	-0.51	-0.12	-0.09	-0.29	-0.51
Kurtosis	1.62	0.17	-0.07	0.03	0.65
No. Negative Quarters	18	22	23	22	21

Panel B: Portfolios With Viatical Settlements

	Cons.	Moderately Cons.	Balanced	Moderately Aggressive	Aggressive
Total return over period	138.21%	160.27%	177.08%	168.93%	165.26%
Mean return (QTR)	1.37%	1.51%	1.61%	1.56%	1.54%
Annualized	5.57%	6.16%	6.58%	6.38%	6.29%
Median return (QTR)	2.17%	-0.13%	-1.98%	-2.16%	-2.01%
Annualized	8.98%	-0.53%	-7.70%	-8.38%	-7.80%
Standard Deviation	4.13%	4.84%	5.89%	6.92%	8.20%
Annualized	8.26%	9.69%	11.78%	13.85%	16.40%
Maximum (QTR)	12.46%	14.00%	16.23%	17.71%	21.44%
Minimum (QTR)	-10.85%	-10.87%	-13.26%	-14.32%	-21.61%
Skewness	-0.07	0.17	0.18	0.03	-0.19
Kurtosis	1.77	1.19	0.70	0.46	0.69
No. Negative Quarters	21	23	22	20	21

Panel C: Portfolios Without Viatical Settlements (Financial Crisis Period 2008Q1- 2009Q4)

	Conservative	Moderately Conservative	Balanced	Moderately Aggressive	Aggressive
Total return over period	-0.49%	-4.90%	-10.51%	-17.40%	-23.70%
Mean return (QTR)	-0.06%	-0.63%	-1.38%	-2.36%	-3.32%
Annualized	-0.24%	-2.48%	-5.40%	-9.12%	-12.65%
Median return (QTR)	-0.59%	-1.79%	-4.02%	-4.75%	-5.21%
Annualized	-2.32%	-6.97%	-15.14%	-17.70%	-19.26%
Standard Deviation	4.89%	6.49%	9.12%	10.92%	13.40%
Annualized	9.77%	12.99%	18.24%	21.83%	26.80%
Maximum (QTR)	7.03%	9.99%	13.64%	14.68%	16.08%
Minimum (QTR)	-7.68%	-9.08%	-12.07%	-15.82%	-24.92%
Skewness	-0.03	0.57	0.67	0.49	0.00
Kurtosis	-1.15	-0.85	-1.05	-1.36	-0.82
No. Negative Quarters	4	5	5	5	5

Panel D: Portfolios With Viatical Settlements (Financial Crisis Period 2008Q1- 2009Q4)

	Conservative	Moderately Conservative	Balanced	Moderately Aggressive	Aggressive
Total return over period	5.87%	1.89%	-3.03%	-9.05%	-14.60%
Mean return (QTR)	0.72%	0.23%	-0.38%	-1.18%	-1.95%
Annualized	2.89%	0.94%	-1.53%	-4.63%	-7.59%
Median return (QTR)	2.17%	-0.13%	-1.98%	-2.16%	-2.01%
Annualized	8.98%	-0.53%	-7.70%	-8.38%	-7.80%
Standard Deviation	6.08%	7.60%	9.68%	11.16%	13.07%
Annualized	12.16%	15.21%	19.36%	22.31%	26.14%
Maximum (QTR)	11.06%	13.45%	16.23%	17.46%	18.88%
Minimum (QTR)	-9.75%	-10.87%	-13.26%	-14.32%	-21.61%
Skewness	-0.16	0.25	0.37	0.31	0.02
Kurtosis	-0.08	-0.90	-1.23	-1.56	-1.25
No. Negative Quarters	3	4	4	4	4

Table VIII

CAPM Regressions for Investment Portfolios

This table presents the market model examination of the representative portfolios (five portfolios formed according levels of risk aversion). Panel 'A' examines the excess return and systematic risk of both sets of representative portfolios (with and without viatical/life settlements) using the CAPM as follows:

$$R_{it} - R_f = \alpha_i + \beta_i(R_{mt} - R_f) + \epsilon$$

Where R_{it} is portfolio return at time t, R_f is the risk free rate, and R_{mt} is the market return at time t.

Panel 'B' examines the excess return and systematic risk of both sets of representative portfolios during periods of economic down turn using the following equation:

$$R_{it} - R_f = \alpha_p + \beta_p(R_{mt} - R_f) + D_{fc}\left(\alpha_p^{fc} + \beta_p^{fc}(R_{mt} - R_f)\right) + \epsilon$$

Where R_{it}, R_{mt}, and R_f are as previously defined, D_{fc} is a series of dummy variables that takes the value of '1' during time of economic crisis (2008Q1 – 2009Q4).

Panel A: CAPM Regression over Entire Sample

		Conserv.	Mod. Conserv.	Bal.	Mod. Aggr.	Aggr.
Portfolios Without Viatical Settlements	Alpha	0.3101	0.2385	0.1980	-0.0265	-0.2097
		(0.95)	(0.83)	(0.60)	(0.14)	(1.56)
	Beta	0.1843***	0.3862***	0.5812***	0.7786***	0.982***
		(3.59)	(8.75)	(11.60)	(29.68)	(54.14)
Portfolios With Viatical Settlements	Alpha	0.0031	0.0026	0.0019	-0.0001	-0.0016
		(0.65)	(0.53)	(0.39)	(-0.02)	(-0.36)
	Beta	0.1817***	0.3440***	0.4999***	0.6607***	0.8514***
		(3.37)	(6.47)	(9.17)	(12.90)	(16.24)

Panel B: CAPM Regressions Including Dummy Variable for Financial Downturn (2001Q3 - 2002Q4)

Portfolios Without Viatical Settlements	Alpha	0.2462	0.1796	0.1263	-0.0892	-0.2533*
		(0.85)	(69)	(0.42)	(-0.51)	(-1.68)
	Beta	0.1681***	0.3644***	0.5510***	0.7479***	0.9504***
		(4.54)	(11.09)	(14.53)	(33.84)	(49.42)
	Alpha-Crisis	0.0008	0.0709	0.0338	-0.1450	-0.1599
		(0.00)	(0.12)	(0.05)	(-0.37)	(-0.47)
	Beta-Crisis	0.0284	0.0458	0.0601	0.0721**	0.0814***
		(0.48)	(0.88)	(1.09)	(2.06)	(2.67)
Portfolios With Viatical Settlements	Alpha	0.0024	0.0019	0.0014	-0.0003	-0.0017
		(0.43)	(0.37)	(0.25)	(-0.05)	(-0.32)
	Beta	0.1587**	0.3159***	0.4652***	0.6227***	0.7839***
		(2.21)	(4.48)	(6.44)	(9.18)	(11.67)
	Alpha-Crisis	0.0073	0.0079	0.0076	0.0061	0.0058
		(0.58)	(0.63)	(0.59)	(0.51)	(0.47)
	Beta-Crisis	0.073	0.0866	0.1026	0.1078	0.1147
		(0.64)	(0.78)	(0.89)	(1.00)	(1.08)

Chapter 3:

Cost of Equity Capital for the Medical Device Industry Under Time-Varying Beta and Risk Free Rate

I. Introduction

This paper examines the cost of equity capital for a sample of publicly traded medical device firms[32] between 1963 and 2008. First we employ two standard frameworks frequently used to examine cost of equity capital: 1) the capital asset pricing model (CAPM), and (2) the Fama-French 3 factor model (Fama and French, 1992 & 1993) to arrive at a single period cost of equity estimate. Next we employ the time varying input model developed by Ang and Liu (2004) to create a term structure of cost of equity for the medical device manufacturing industry.

Both the ubiquitous CAPM and its improved alternative, the Fama-French 3 Factor model, produce a single-period cost of equity. Unfortunately, the shortcomings of using a single-period discount rate to determine the present value of a series of cash flows has been regularly discussed since the mid 1960's (Robichek and Myers, 1966; Chen, 1967). Robichek and Myers (1966) point out that without satisfying certain specific assumptions, firms will make "incorrect decisions" when relying upon a single discount rate. The use of a single-period discount rate will result in the overstating of some periods' present values while understating others; the hope is that these conflicting errors will cancel out (Robichek and Myers, 1966).

[32] While we will be examining the medical device industry, between 75% and 89% of all firms use discount cash flow (DCF) analysis and employ cost of capital as the discount rate (Bruner, Eades, Harris & Higgens, 1998; Graham and Harvey 2001)

Robichek and Myers (1966) espouse one possible alternative to the single discount rate problem, the certainty equivalent approach used to value each cash flow. The certainty equivalent approach entails determining a certain (or risk free) amount you would be willing to take in exchange for the unknown risky future cash flow. While this allows for each cash flow to face different risk assumptions (i.e. the equivalent of a different discount rate or each cash flow), it is seldom, if at all, used in practice. The lack of widespread adoption of the certainty equivalent approach is most likely due to its complexity and the inherent preference we have for interest rates (Wilson and Shailer 2004).

Given the widely acknowledged deficiency of a single discount rate it is surprising that little research has been done to estimate a term structure of the cost of equity capital. See Brennen (1997), Wilson and Shailer (2004), and Ang and Liu (2004) as notable exceptions.

Ang and Liu (2004) point out that volumes of research have illustrated that the risk free rate, firm beta, and market risk premium are very likely to *not* be constant. As with the few prior attempts at developing time varying discount rates (i.e. a term structure of the cost of equity capital), Ang and Liu (2004) describe the typical steps involved in valuing a cash flow stream: 1) estimate expected future cash flows for the project; 2) calculate the present value of all the project's cash flows, typically using a single discount rate. The authors go onto briefly describe the approach taken by Brennen (1997) then proceed to develop a generalized version of his model.

Ang and Liu (2004) develop a term structure of interest rates and use a $1 perpetuity to compare it to the traditional, static, CAPM. They find an average mis-pricing error across all firms of -15.31% across book-to-market portfolios (i.e. the CAPM undervalues the perpetuity by 15.31% compared to the proper term structure approach) and -17% across industry portfolios. In examining the individual industries, Ang and Liu (2004) find that the two largest mispricing errors are in the fabricated products and shipping industries, (-33% and -58%) respectively.

II. Capital Asset Pricing and Fama-French 3 Factor Models

Both the CAPM and the Fama-French 3 Factor Model attempt to estimate a security's required rate of return as a linear function of either one or three risk factors. Developed by Sharpe (1964) and Lintner (1965a,b), the Capital Asset Pricing Model posits that an asset's return is a function of the risk free rate, the market risk premium, and the asset's systematic risk exposure. The CAPM is expressed as shown below:

$$E(r_i) = RF + (RPM)\beta_i \quad (1)$$

Where $E(r_i)$ is the expected return on asset i, RF is the risk free rate, β_i is the beta coefficient for asset i, and RPM is the market risk premium.

Since its development, the CAPM has been the de rigueur method among practitioners to determine a firm's cost of equity. Graham and Harvey (2001) find

that 73.5% of CFOs always or almost always rely upon the CAPM to determine cost of equity capital. Additionally, of the nearly 90% of firms that rely on DCF analysis to evaluate capital budgeting options in Bruner, Eades, Harris, and Higgens (1998), 89% use the CAPM to determine cost of equity. However, despite the overwhelming adoption of CAPM for cost of equity estimation, empirical evidence has repeatedly called into question the accuracy of the required returns calculated using CAPM.

In response to the criticisms of the traditional CAPM made by Basu (1983), Banz (1981), Bhandari (1988), Statman (1980), and Rosenberg, Reid and Lanstein (1985)(and others), Fama and French (1992) developed a three-factor model that incorporates two additional risk factors (firm size and book to market value ratio) into the traditional CAPM. The Fama-French 3 Factor Model expressed as shown below:

$$E(r_{i,t}) = RF_t + \beta_{i,MKT}(RPM) + \beta_{i,SMB}(SMB) + \beta_{i,HML}(HML) \quad (2)$$

Where $E(r_{i,t})$ is the expected return on asset i for time t, RF is the risk free rate, $\beta_{i,MKT}$ is the beta coefficient for asset i with regards to the market risk premium, RPM is the market risk premium, $\beta_{i,SMB}$ is the beta coefficient for asset i with regards to the firm size risk factor, SMB is the return on a portfolio of small stocks minus the return on a portfolio of large stocks, $\beta_{i,HML}$ is the beta coefficient for asset i with regards to the book-to-market ratio risk factor, and finally, HML is the return on a portfolio of stocks with high book-to-market ratios minus the return on a portfolio of stocks with low book-to-market ratios. Despite evidence that multifactor models such as the Fama-French 3 Factor Model significantly outperform the traditional

capital asset pricing model, less than 35% of firms use these models in estimating cost of equity capital (Graham and Harvey 2001; Bruner, Eades, Harris, and Higgins 1998).

III. Time Varying Cost of Equity

The price, or present value, (P_t) of all future cash flows (C_t) generated by a firm's assets is given by:

$$P_t = \sum_{\tau=1}^{\infty}(E_t C_{t+\tau})e^{-\tau\rho(\tau)_t}. \quad (3)$$

Where $\rho(\tau)_t$ is the cost of capital, as of the end-of-period t, for a single cash flow expected at time $t+\tau$. Under standard valuation and capital budgeting practices, $\rho(\tau)_t$ is typically considered constant over time. At best, one or two 'abnormal' discount rates are estimated for the early periods, while a constant rate is assumed for longer-term cash flows. However, if we consider the firm's future cash flows akin to a series of zero coupon bonds each with a time to maturity of τ, $\rho(\tau)t$ takes on the same interpretation as the yield to maturity on a zero coupon bond. This permits us to develop a term structure of cost of equity capital and thereby avoid the pitfalls that accompany employing a single, constant, discount rate.

First, we define the present value, $V(\tau)$, of the single cash flow $C_{t+\tau}$ as of time t as follows:

$$V(\tau)_t = e^{-\tau\rho(\tau)}[E_t C_{t+\tau}]. \quad (4)$$

Next, we define the continuously compounded expected return, μ_t, earned by holding a τ period cash flow from time period t to t+1 as:

$$\mu_t = E_t \ln(V(\tau-1)_{t+1})/V(\tau)_t. \quad (5)$$

Assuming the terminal value, $V(0)_{t+\tau}$, equals the actual time $t+\tau$ cash flow itself, $C_{t+\tau}$, this equation can be solved forward to arrive at $V(\tau) = E_t\left[e^{-(\mu_t+\cdots+\mu_{t+\tau-1})}C_{t+\tau}\right]$. If we now turn our attention to the zero coupon cash flows and assume that they grow at a rate of g_t, where $g_t = \ln(C_t/C_{t-1})$, the time t present value of cash flow $C_{t+\tau}$ can be shown to be a function of both cash flow growth rates and single period expected returns:

$$V(\tau)_t = E_t\left[e^{-(\mu_t+\cdots+\mu_{t+\tau-1})}C_t e^{(g_{t+1}+\cdots+g_{t+\tau})}\right]. \quad (4)$$

In order to estimate a term structure of discount rates, we must first put the above equations into the context of a single period equilibrium model, namely the Capital Asset Pricing Model (CAPM) given below:

$$\mu_t = RF_t + (RPM)\beta_t. \quad (5)$$

Where RF_t is the end of period t observed risk free rate, RPM is the constant market risk premium, and β_t is the time varying systematic risk exposure factor (beta). The stochastic components in equation (5), RF_t and β_t, are combined with the cash flow growth rate, gt, in a 1x3 vector $Y_t' = (g_t, RF_t, \beta_t)$. We can model the time series dynamics with the vector autoregression (VAR):

$$Y_{t+1} = \overline{Y} + \Phi Y_t + \varepsilon_t, \quad (6)$$

where $\varepsilon_{t+1} \sim N(0,\Omega)$. Next we can define i_1' as a 1x3 row vector of zeros with a 1 in first column. Consequently, we can show that $g_{t+1} = i_1'Y_{t+1}$ and that the single period CAPM expected return is $\mu_t = \lambda' Y_t$, where $\lambda' = (0, 1, RPM)$.

Applying the cash flow growth rate, $g_{t+1} = i_1'Y_{t+1}$, we can determine the t+1 expected cash flow as follows: $E_t[C_{t+1}] = C_t e^{i_1'(\overline{Y}+\Phi Y_t)+(1/2)i_1'\Omega i_1}$. We now define

scalar variable $\bar{a}(1) = i_1'\bar{Y} + (1/2)i_1'\Omega i_1$ and the 1x3 row vector $\bar{b}(1)' = i_1'\Phi$. The expected cash flow for period t+1 is now given by $E_t[C_{t+1}] = C_t e^{\bar{a}(1)+\bar{b}(1)'Y_t}$.

This can be generalized to arrive at the following expected period t+τ cash flow:

$$E_t C_{t+\tau} = C_t e^{\bar{a}(\tau)+\bar{b}(\tau)'Y_t}. \quad (7)$$

Where the coefficients $\bar{a}(\tau)$ and $\bar{b}(\tau)$ are given by the following recursions:

$$\bar{a}(\tau) = \bar{a}(\tau-1) + \left[i_1 + \bar{b}(\tau-1)\right]'\bar{Y} + (1/2)\left[i_1 + \bar{b}(\tau-1)\right]'\Omega\left[i_1 + \bar{b}(\tau-1)\right]$$

$$\bar{b}(\tau)' = \left[i_1 + \bar{b}(\tau-1)\right]'\Phi$$

Substituting equation (7) into equation (3) and we arrive at the general form of the present value of cash flow t+τ:

$$V(\tau)_t = e^{-\tau\rho(\tau)_t}\left[C_t e^{\bar{a}(\tau)+\bar{b}(\tau)'Y_t}\right]. \quad (8)$$

Alternatively, we can determine the present value of the time t+1 period cash flow using equation 4 and the single period CAPM determined discount rate. Recall that the t+1 growth rate is given by: $g_{t+1} = i_1'Y_{t+1}$, and the single period CAPM cost of equity capital is given by: $\mu_t = \lambda' Y_t$. Substituting into equation (4) the present value of period t+1 cash flow is:

$$V(1)_t = C_t E_t\left[e^{i_1'Y_{t+1}-\lambda'Y_t}\right] = C_t e^{i_1'(\bar{Y}+\Phi Y_t)+(1/2)i_1'\Omega i_1-\lambda'Y_t}. \quad (9)$$

We can now define scalar a(1), and row vector b(1)' as follows:

$a(1) = i_1'\bar{Y} + (1/2)i_1'\Omega i_1$, $b(1)' = -\lambda' + i_1'\Phi$. Presume that for $C_{t+\tau}$ the present value is:

$$V(\tau)_t = C_t\left[e^{a(\tau)+b(\tau)'Y_t}\right], \quad (10)$$

and that we can estimate V(τ)t by discounting the next period value of the cash flow: $V(\tau)_t = E_t[e^{-\mu_t}V(\tau-1)_{t+1}]$. Applying equation (10) to $V(\tau\text{-}1)_{t+1}$ we obtain:

$$V(\tau)_t = C_t e^{-\lambda' Y_t + i_1'(\bar{Y}+\Phi Y_t)+\frac{1}{2}i_1'\Omega i_1 + a(\tau-1)+b(\tau-1)'(\bar{Y}+\Phi Y_t)+\frac{1}{2}b(1)'\Omega b(1)}. \quad (11)$$

If we equate the exponents in equations (10) and (11) we arrive at the following recursions:

$$a(\tau) = a(\tau-1) + [i_1 + b(\tau-1)]'\bar{Y} + \frac{1}{2}[i_1 + b(\tau-1)]'\Omega[i_1 + b(\tau-1)]$$

$$b(\tau)' = -\lambda' + [i_1 + b(\tau-1)]'\Phi \quad (12)$$

The cost of capital, ρ(τ)t, is determined by setting equation (8) equal to equation (11) and is as follows:

$$\rho(\tau)_t = \frac{1}{\tau}\left\{\bar{a}(\tau) - a(\tau) + \left[\bar{b}(\tau) - b(\tau)\right]' Y_t\right\}. \quad (13)$$

Equations (13) gives us the term structure of cost of equity capital.

We can examine a brief numerical example of the time varying cost of equity model. Let us assume that beta is the only stochastic variable – in other words, the risk free rate, cash flow growth rate, and the market risk premium are all fixed. For our example, the cash flow growth rate is 5%, the risk free rate is 3%, and the market risk premium is 7%. Furthermore, the long-term average beta for the medical device industry over our sample is 0.94 with a maximum of 1.38, a minimum of 0.36, and a variance of approximately 0.078. We will look at three cases, Φ = 0.7, Φ = 0.3 and Φ = 0.0 for both the maximum beta (1.38) and the minimum beta (0.36).

The tables below presents selected results from a 30-year term structure of the cost of capital constructed from our example outlined above.

Maximum observed beta over sample (1.38)

Maximum Beta (1.36)			
Tau	Phi =0.7	Phi=0.3	Phi=0.00
1	12.66%	12.66%	12.66%
5	18.07%	12.45%	10.18%
10	20.84%	12.40%	9.87%
15	22.07%	12.39%	9.77%
20	22.73%	12.38%	9.72%
25	23.12%	12.38%	9.68%
30	23.39%	12.38%	9.66%

Minimum observed beta over sample (0.36)

Minimum Beta (0.36)			
Tau	Phi =0.7	Phi=0.3	Phi=0.00
1	5.52%	5.52%	5.52%
5	14.11%	10.41%	8.75%
10	18.53%	11.38%	9.16%
15	20.49%	11.71%	9.29%
20	21.54%	11.87%	9.36%
25	22.17%	11.97%	9.40%
30	22.60%	12.04%	9.43%

Here we can see in this hypothetical example when using the maximum observed beta (1.38) we have an upward sloping term structure when $\Phi = 0.7$, a downward sloping term structure when $\Phi = 0.3$ and an essentially flat term structure when $\Phi = 0.0$. When using the minimum observed beta (0.36) we find that for all values of Φ the term structure is upward sloping.

The term structure shapes described above make intuitive sense if we examine the long run mean beta for each case (i.e. for $\phi=0.7$, $\phi=0.3$, and finally for

ϕ=0.0). With a historical average beta of 0.94 a ϕ=0.7 yields a long run mean beta of 0.94/(1-0.07) = 3.13, a ϕ=0.3 yields a long run mean beta of 0.94/(1-0.3)=1.34, and finally, a ϕ=0.0 yields a long run mean beta of 0.94/(1-0.0) = 0.94. The long run mean betas for each phi presented above are independent of the current beta, and therefore, are the long run mean betas for both the high beta (1.38) and low beta (0.36) scenarios described in the numerical example.

If we look first to the high beta scenario we see that with a phi of 0.7 the current beta of 1.38 is below the long run mean of 3.13. Therefore, over time, the industry beta will drift up from 1.38 towards 3.13, thus presenting us with an upward sloping term structure. If phi equals 0.30 the long run average beta is nearly equal to 1.38, therefore we see little change in the term structure over time. Finally, when phi equals 0.0 the long run average beta of 0.94 is below the current beta of 1.38 and we see that the industry beta will drift down towards 0.94, thus presenting us with a downward sloping term structure.

Similarly, if we look at the low beta scenario we find that in all cases (ϕ=0.7, ϕ=0.3, and ϕ=0.0) the long run average betas are greater than 0.36. Therefore, over time, the beta in each case will drift up from 0.36 to the long run mean. As a result, all three cases display an upward sloping term structure with ϕ=0.7 resulting in the steepest slope and ϕ=0.0 resulting in the lowest slope.

Now we can compare the cost of equity term structure for the medial device industry to the ubiquitous single period CAPM cost of equity estimate as well as the less often used single period Fama-French 3 Factor cost of equity estimates.

As previously noted, cost of equity plays a pivotal roll in the capital budgeting decision-making process for each firm[33]. The predominant capital budgeting decisions of medical device manufacturing firms revolves around research and development investment. As such we will examine the impact of a term structure of cost of equity rates as well as the traditional measures of cost of equity on R&D spending.

It is intuitive that as a medical device manufacturing firm's cost of equity decreases, it will be more willing to invest in research and development[34] and vice-versa when the firm's cost of equity increases. We begin our analysis by regressing industry research and development intensity on our static estimates of industry cost of equity capital using both the traditional CAPM as well as the Fama-French 3 Factor Model using the following equation:

$$RDS_t = \alpha + \beta_1 COEC_{t,j} + \varepsilon_t. \quad (14)$$

Where RDS_t is research and development investment intensity (R&D investment scaled by sales) in time 't', $COEC_{t,j}$ is the single period estimated cost of equity capital for time 't' using method 'j' (CAPM or Fama-French 3 Factor).

Several studies have examined the predictive power of the term structure of interest rates (Estrella and Hardouvelis, 1991; Bernard and Gerlach 1998, and Estrella and Mishkin 1997 & 1998 among others). Estrella and Hardouvelis (1991)

[33] A high cost of equity will decrease the net present value of all the firm's investment alternatives, and it will raise the hurdle rate used to evaluate a project's IRR

[34] Even if we limit the firm's investible capital to internally available funds, investors will still demand those funds be put to work at the cost of equity therefore, our analysis should stand for firms that rely on both external and internal financing.

find that an upward sloping treasury yield curve is associated with increases in future real economic activity (i.e. consumption and investment). Likewise, Bernard and Gerlach (1996) find that the term structure of government securities in eight countries is able to predict future recessions (i.e. economic activity). Furthermore, in a later paper, Estrella and Mishkin (1997) demonstrate that the interest rate term structure contains "significant" predictive power with regards to real economic activity and inflation.

Estrella and Hardouvelis (1991), Bernard and Gerlach (1996), and Estrella and Mishkin (1997 & 1998) each use the spread between the long-term and short-term rates as a measure of the interest rate term structure.

In their exploration of eight countries[35] Bernard and Gerlach (1996) use a probit regression with 'SPREAD', the difference between the long and the short interest rate, as the independent variable to evaluate the predictability of future recessions. Estrella and Mishkin (1998) also examine recession and interest rate term structure spread via a probit regression with 'SPREAD' as a right hand side variable in the United States, the United Kingdom, France, Germany, and Italy. Additionally, they employ 'SPREAD' as an independent variable to evaluate predictability in real GDP and inflation (Estrella and Mishkin 1998). Finally, Estrella and Hardouvelis (1991) use U.S. Treasury spread as a right hand side variable in a regression testing the predictability of changes in real output as well as the individual components of GNP. Furthermore, they reveal that U.S. Treasury spread

[35] Belgium, Canada, France, Germany, Japan, the Netherlands, the United Kingdom, and the United States

is a better predictor of future GNP growth than the ASA/NBER Survey Forecasts. Figure 1 presents the spread between the 30 year and 1 year cost of capital estimates in our term structure for each year in our sample.

Following the examination of the predictive power of government security term structure on macro economic concerns, we employ the spread in our estimated cost of equity term structure to evaluate R&D investment at the industry level using the following regression equation.

$$RDS_t = \alpha + \beta_1(SPREAD_t) + \varepsilon_t. \quad (15)$$

Where, RDS_t is research and development intensity at time 't', and $SPREAD_t$ is the spread between the 30 year and the 1 year cost of equity for year 't'.

In addition to its key role in capital budgeting, the cost of equity capital will influence a firm's capital structure and financing decisions. Along with other factors, a low cost of equity capital should lead to a higher number of equity issues than higher equity capital costs. To examine the relation between industry cost of equity capital and the number of equity issuances within our sample we will evaluate the following equation:

$$ISSUE_t = \propto + COEC_{j,t} + \varepsilon_t. \quad (16)$$

Where $ISSUE_t$ is the number of firms issuing equity in our sample during year 't', $COEC_{jt}$ is the single period, industry cost of equity capital for year 't' calculated using method 'j' (CAPM or Fama-French 3 Factor).

Next we turn again to our term structure of the cost of equity capital for the medical device industry. Specifically, we examine the impact of the spread between the 30 year term cost of equity capital and the 1 year term cost of equity capital on the number of firms issuing equity in our sample each year using the following equation:

$$ISSUE_t = \alpha + \beta_1 (SPREAD_{j,t}) + \varepsilon_t. \quad (17)$$

Where $ISSUE_t$ is as defined above, and $SPREAD_t$ is the spread between the 30 year and 1 year cost of equity capital in year 't'.

For our analysis we will follow Hovakimian (2004), Korajczyk and Levy (2003) and Leary and Roberts (2005) in our definition of an equity issuance. An increase of 5% or more in common equity, normalized by book value of assets, shall indicate an equity issuance.

IV. Data and Sample

The focus of this essay is to examine the cost of equity for medical device manufacturing industry; as such, we limit our sample to firms that solely operate in the medical device industry. While seemingly straight forward, many of the firms in the medical device industry that have substantial longitudinal data available also derive significant revenues from other industries (i.e. pharmaceuticals, consumer goods, etc…). Using Standard and Poor's Compustat database, we created a sample of 20 medical device manufacturing firms that have at least 10 years of data

available ending in 2008. This gives us an unbalanced panel starting in 1963 and continuing to 2008 and contains a total of 513 firm-year observations. Please see Table I for a list of the firms used in this essay, the range of data used for each firm, sample ending (2008) market value weight for each firm, average annual R&D investment scaled by sales for each firm, and the total number of equity issuances for each firm in our sample.

We calculate rolling 3-year, monthly betas (both CAPM and Fama-French 3 Factor) for each firm in our sample using firm and index return data obtained from the Center for Research in Security Prices (CRSP), United States Treasury rate data obtained from Ibbotson Associates, and Fama-French SMB and HML factors obtained from Kenneth French's website.

V. Empirical Results

Throughout our examination we will follow Harrington (2009) and assume a constant market risk premium of 0.07, and constant SMB and HML factors of 0.03 and 0.04 respectively.

Table II presents the traditional CAPM and Fama-French 3 Factor model estimates of the industry aggregate cost of equity for our sample of medical device manufacturing firms for the years 1963 – 2008. We can see that using the CAPM (as the overwhelming majority of firms do) results in a maximum beta of 1.38 in 1977 and a minimum beta of 0.36 in 2003. While the minimum beta of 0.36 in 2003 gives

us the lowest cost of equity for the aggregate sample, 3.53%, the maximum cost of equity, 21.59%, occurs in 1982. Similarly, we find the maximum cost of equity using the Fama-French 3 Factor model, 18.85% occurs in 1981 as well, while the lowest Fama-French 3 Factor cost of equity, 5.06% is in 1963. Figure (1) presents a graphical representation of each year's CAPM and Fama-French 3 Factor cost of equity.

Tables III presents the term structure of the industry aggregate cost of equity for the years 1963 – 2008 using equation (15). As can be seen in a comparison of the single period models, our term structure model presents and entirely different picture of the industry's required return for each year.

Figures 2 – 6 illustrate the term structure of industry cost of equity capital for each year in our sample[36]. We can clearly see that our term structure model estimates a variety of upward sloping, downward sloping, and relatively flat yield curves. This serves as a striking illustration of the deficiency inherent in a single rate model such as the static CAPM or Fama-French 3 Factor model. Next, figure 7 shows the average spread over treasuries for each term. Apart from the 20 year (spread of 4.83%) and the 30 year (spread of 7.05%) the spread above treasuries is typically between 5% and 6%.

Due to the crucial role cost of equity plays in the capital budgeting process it is prudent to examine the cost associated with using an incorrect, single period, discount rate when evaluating future cash flows. Table IV reports the valuation

[36] Each figure contains the annual industry cost of equity capital term structure for each decade in our sample.

error resulting from not using a term structure of discount rates when valuing a 30 year $1.00 annuity. Columns 2 through 4 show the value of this annuity using the static CAPM, the static Fama-French Three Factor model, and finally the term structure cost of equity. Columns 5 & 6 as well as 7 & 8 show the percent error and absolute value of the percent error resulting from discounting with either of the two static cost of equity capital rates.[37] We find a maximum overvaluation of 11.50% and maximum undervaluation of 37.46% when comparing the present value obtained using the static CAPM versus the term structure model. Likewise, we find a maximum overvaluation of 53.66% and a maximum undervaluation of 34.38% when comparing present values calculated using the Fama-French Three Factor model. Over our sample, we also find a mean (median) absolute value error of 8.62% (5.12%) and 24.45% (25.00%) for the CAPM and Fama-French derived cost of equity capital respectively.

Table V presents the OLS regression results of equations (14) and (15). Columns 2 and 3 use the traditional CAPM cost of equity and the Fama-French 3 Factor cost of equity, respectively, as the independent variable in equation (14). Column 3 use the spread between the 30 year and 1 year cost of equity rates as an independent variable in equation (15).

We can see that both the CAPM and Fama-French single period cost of equity estimates display a statistically significant (at 5% and 1% levels respectively) negative relation with research and development investment (RDS). As the current

[37] Percent error is calculated as follows [(single period cost valuation – term structure cost valuation)/term structure cost valuation]

cost of equity capital increases, research and development intensity decreases. Also, we find that the cost of capital equity term structure spread is a significant determinant of research and development intensity. There is a positive relation between spread and R&D investment (significant at the 5% level). When the industry faces an upward sloping cost of equity term structure firms will increase their research and development spending intensity (i.e. R&D spending as a percent of sales). Similarly, if the spread between the 30 year and 1 year costs of equity is negative, firms will scale back R&D intensity.

Next we look the number of equity issuances. Table VIII presents the results from the OLS regression of equations (16) and (17). As expected we find a very strong, statistically significant, negative relation between the cost of equity capital and equity issuance for both the static CAPM and Fama-French 3 Factor Model derived cost of equity capital estimates (both significant at the 1% level). The number of firms issuing equity decreases as the current cost of equity increases. When we turn to the term structure of cost of equity capital, we find a large, statistically significant, positive relation between equity issuances and the spread in our cost of capital term structure (significant at the 1% level). This indicates that when faced with an upward sloping cost of equity capital term structure firms choose to issue equity.

VI. Conclusion

In this paper we employ the model developed by Ang and Liu (2004) to estimate a term structure of equity cost of capital for firms within the medical device manufacturing industry based upon the Capital Asset Pricing Model. Using this term structure estimate of the cost of equity capital (from 1 to 30 years) we show that firms in our sample have the potential to incorrectly value long-term project by up to 53%. They also display average valuation error of 8.63% or 24.45% when using a single period CAPM or Fama-French cost of equity capital estimates respectively instead of a term structure of discount rates.

Furthermore, we find evidence that the spread between the 30 year and 1 year cost of equity is significantly and positively related to R&D intensity. Firms facing upward sloping cost of equity capital term structures increase their investment (measured in our sample by research and development intensity); while a downward sloping term structure (negative spread) would lead to a reduction in R&D intensity.

Similarly, we find the term structure spread is significantly and positively, related to the decision to issue equity. Therefore, more firms in our sample issue equity when facing an upward sloping cost of equity term structure.

This paper examines the aggregate cost of equity capital for the sample of firms within the medical device manufacturing industry that are solely medical device manufacturers. Further work in this area could examine firm specific cost of

equity capital term structures as well as examine industries beyond medical device manufacturing.

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Tables and Figures

Table I

Medical device firms examined

This tables lists the medical device manufacturing firms used in this essay, the dates data was available, each firm's percent of the sample (based upon 2008 market value), and finally each firm's average RDS.

Firm	Date Range	Mrk Val Weight	Average	# Equity
ATRION CORP	1973 - 2008	0.13%	0.0785	21
ATS MEDICAL INC	1990 - 2008	0.13%	0.3683	5
BAXTER INTERNATIONAL INC	1962 - 2008	22.33%	0.0541	17
BECTON DICKINSON & CO	1963 - 2008	13.20%	0.0511	7
BIOJECT MEDICAL	1988 - 2008	0.00%	1.2953	6
BOSTON SCIENTIFIC CORP	1992 - 2008	7.86%	0.1546	5
CONCEPTUS INC	1996 - 2008	0.31%	8.0503	2
HAEMONETICS CORP	1991 - 2008	0.95%	0.0633	8
HILL-ROM HOLDINGS INC	1971 - 2008	1.28%	0.0175	7
INTEGRA LIFESCIENCES HLDGS	1995 - 2008	0.67%	0.3293	5
KENSEY NASH CORP	1996 - 2008	0.25%	0.4472	2
MEDTRONIC INC	1973 - 2008	24.23%	0.0995	11
MERIT MEDICAL SYSTEMS INC	1990 - 2008	0.34%	0.0598	5
ROCHESTER MEDICAL CORP	1991 - 2008	0.11%	0.1482	4
SMITH & NEPHEW PLC	1999 - 2008	3.86%	0.0391	9
ST JUDE MEDICAL INC	1977 - 2008	7.70%	0.1015	4
STERIS CORP	1992 - 2008	0.92%	0.0482	9
STRYKER CORP	1979 - 2008	10.71%	0.0568	9
SYNOVIS LIFE TECH INC	1987 - 2008	0.14%	0.0751	3
VARIAN MEDICAL SYSTEMS INC	1962 - 2008	4.85%	0.0647	12

Figure 1

Spread Between 30 Year and 1 Year Cost of Equity

This figure presents the spread between the 30 year and 1 year cost of equity for each year in our sample.

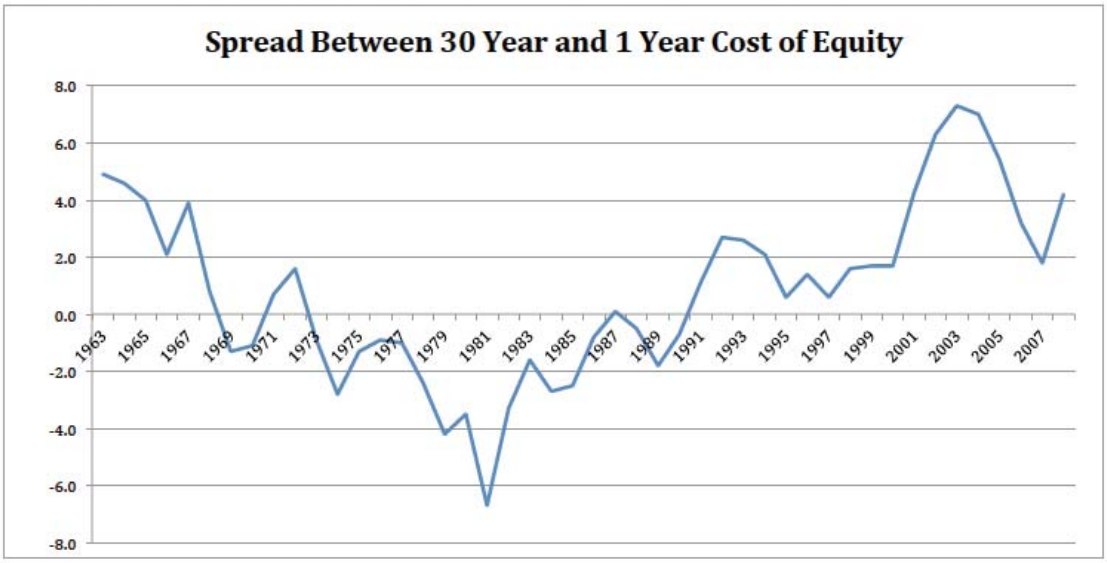

Table II

Single period CAPM and Fama-French 3 Factor cost of equity estimates

CAPM and Fama-French 3 Factor cost of equity estimates for entire sample of medical device manufacturers from 1963 through 2008. The CAPM betas were estimated in aggregate for our firms using the following regression equation $R_t = RF_t + (RPM)\beta_t + \varepsilon_t$, while the 3 factor model used followed Fama-French (1992) and used the following regression equation $R_t = RF_t + (RPM)\beta_{t,MKT} + (SMB)\beta_{t,SMB} + (HML)\beta_{t,HML} + \varepsilon_t$. Following Harrington (2009) cost of equity is calculated using a constant market risk premium of 0.07, and constant SMB and HML risk premiums of 0.03 and 0.04 respectively. Also displayed in the table are the CAPM market betas for each year as well as the Fama-French 3 Factor Market, SMB, and HML betas for each year.

Year	CAPM	*CAPM*	Mkt	SMB	HML	*FF 3 F*	Year	CAPM	*CAPM*	Mkt	SMB	HML	*FF 3 F*
1963	0.49	***6.56***	0.359	0.562	(0.563)	***5.06***	1986	1.18	***14.40***	0.860	(0.064)	(0.787)	***8.84***
1964	0.49	***6.98***	0.359	0.562	(0.563)	***5.48***	1987	1.10	***13.17***	0.814	(0.222)	(0.936)	***6.76***
1965	0.57	***7.93***	0.365	0.840	(0.627)	***6.49***	1988	1.08	***13.89***	0.811	(0.239)	(0.879)	***7.81***
1966	0.80	***10.37***	0.568	1.211	(0.976)	***8.45***	1989	1.02	***15.53***	0.798	(0.105)	(0.687)	***10.90***
1967	0.56	***8.14***	0.409	0.869	(0.466)	***7.82***	1990	0.87	***13.93***	0.731	(0.224)	(0.484)	***10.35***
1968	1.02	***12.33***	0.726	0.888	(0.757)	***9.94***	1991	0.89	***11.83***	0.808	(0.223)	(0.231)	***9.66***
1969	1.21	***15.05***	0.884	0.684	(0.598)	***12.42***	1992	0.91	***9.85***	0.807	(0.123)	(0.146)	***8.20***
1970	1.19	***14.84***	0.909	0.613	(0.490)	***12.76***	1993	1.01	***9.98***	0.834	(0.168)	(0.409)	***6.60***
1971	1.17	***12.58***	0.984	0.385	(0.233)	***11.50***	1994	0.95	***10.55***	0.763	(0.098)	(0.430)	***7.23***
1972	1.06	***11.26***	0.875	0.456	(0.244)	***10.36***	1995	0.97	***12.40***	0.730	0.073	(0.407)	***9.30***
1973	1.07	***14.40***	0.792	0.593	(0.080)	***13.93***	1996	0.86	***11.22***	0.671	0.069	(0.379)	***8.59***
1974	1.27	***16.87***	1.082	0.128	(0.554)	***13.76***	1997	1.03	***12.47***	0.741	(0.068)	(0.574)	***7.93***
1975	1.34	***15.20***	1.131	0.100	(0.484)	***12.08***	1998	0.91	***11.22***	0.607	(0.131)	(0.508)	***6.68***
1976	1.37	***14.66***	1.179	0.133	(0.577)	***11.42***	1999	0.88	***10.86***	0.714	(0.123)	(0.037)	***9.17***
1977	1.38	***14.79***	1.157	0.135	(0.722)	***10.75***	2000	0.68	***10.67***	0.591	(0.157)	0.128	***10.06***
1978	1.34	***16.54***	1.116	0.279	(0.675)	***13.14***	2001	0.50	***7.37***	0.473	(0.088)	0.247	***7.90***
1979	1.17	***18.58***	0.933	0.457	(0.380)	***16.76***	2002	0.46	***4.86***	0.499	0.020	0.388	***6.74***
1980	0.87	***17.37***	0.616	0.472	(0.325)	***15.69***	2003	0.36	***3.53***	0.445	0.086	0.449	***6.20***
1981	0.98	***21.59***	0.643	0.420	(0.407)	***18.85***	2004	0.40	***4.02***	0.446	0.059	0.389	***6.04***
1982	0.97	***17.35***	0.741	0.301	(0.266)	***15.55***	2005	0.41	***5.88***	0.380	0.190	0.332	***7.54***
1983	0.91	***15.18***	0.720	0.133	(0.341)	***12.87***	2006	0.58	***8.84***	0.409	0.242	(0.152)	***7.79***
1984	0.95	***16.47***	0.706	0.100	(0.489)	***13.13***	2007	0.89	***10.88***	0.844	(0.151)	(0.290)	***8.96***
1985	1.27	***16.60***	0.979	0.154	(0.550)	***12.84***	2008	0.90	***7.93***	0.606	0.034	0.124	***6.48***

Figure I

CAPM and Fama-French 3 Factor Model Cost of equity

This figure presents the aggregate sample (single period) cost of equity using both the CAPM (solid line) and Fama-French 3 Factor model (dashed line) for the years 1963 – 2008.

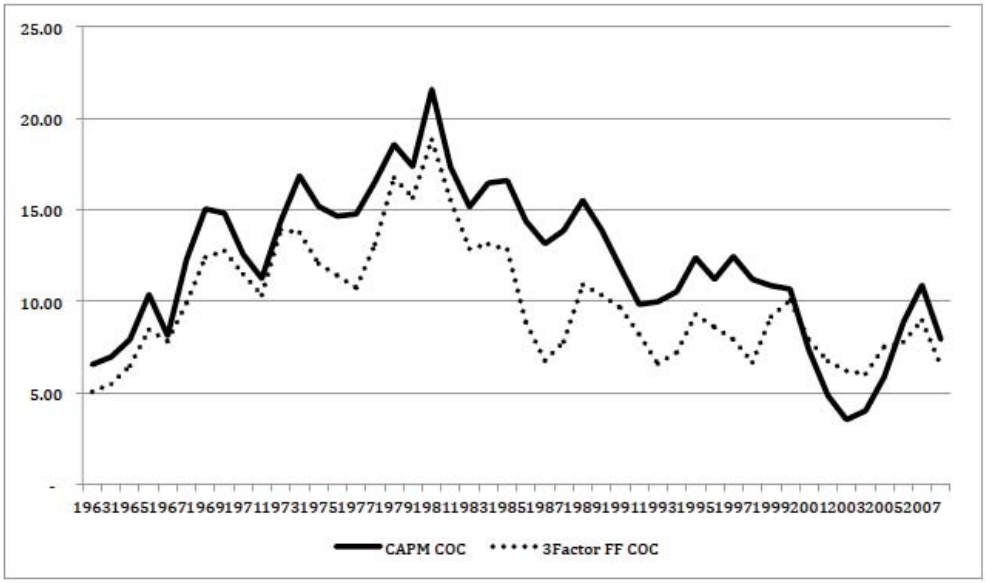

Table III

Term structure of cost of equity

This table presents the term structure of the cost of equity capital for the medical device firms in our sample from 1963 to 2008 as estimated by equation (13), $\rho(\tau)_t = \frac{1}{\tau}\left\{\bar{a}(\tau) - a(\tau) + \left[\bar{b}(\tau) - b(\tau)\right]' Y_t\right\}$, assuming a market risk premium of 0.07.

Year	Term to Maturity (in Years)								Year	Term to Maturity (in Years)							
	1 Yr	3 Yrs	5 Yrs	7 Yrs	10 Yrs	15 Yrs	20 Yrs	30 Yrs		1 Yr	3 Yrs	5 Yrs	7 Yrs	10 Yrs	15 Yrs	20 Yrs	30 Yrs
1963	6.6	7.3	8.0	8.6	9.3	10.2	10.8	11.5	1986	14.4	14.2	14.1	14.0	13.9	13.8	13.7	13.6
1964	7.0	7.6	8.2	8.8	9.5	10.3	10.9	11.6	1987	13.2	13.2	13.2	13.2	13.3	13.3	13.3	13.3
1965	7.9	8.5	9.1	9.5	10.1	10.8	11.3	11.9	1988	13.9	13.8	13.7	13.7	13.6	13.5	13.5	13.4
1966	10.4	10.7	11.0	11.3	11.6	12.0	12.2	12.5	1989	15.5	15.0	14.7	14.5	14.2	14.0	13.8	13.7
1967	8.1	8.8	9.3	9.7	10.2	10.9	11.4	12.0	1990	13.9	13.5	13.4	13.3	13.2	13.2	13.2	13.2
1968	12.3	12.5	12.6	12.7	12.8	12.9	13.0	13.1	1991	11.8	11.9	12.1	12.2	12.3	12.6	12.7	12.9
1969	15.1	15.0	14.8	14.7	14.5	14.2	14.0	13.8	1992	9.8	10.3	10.6	11.0	11.3	11.8	12.1	12.5
1970	14.8	14.7	14.6	14.4	14.3	14.1	13.9	13.7	1993	10.0	10.5	11.0	11.3	11.7	12.1	12.3	12.6
1971	12.6	12.9	13.1	13.1	13.2	13.3	13.3	13.3	1994	10.5	10.8	11.1	11.4	11.7	12.1	12.3	12.6
1972	11.3	11.6	11.9	12.1	12.3	12.6	12.7	12.9	1995	12.4	12.4	12.4	12.5	12.6	12.8	12.9	13.0
1973	14.4	14.3	14.2	14.0	13.9	13.8	13.7	13.5	1996	11.2	11.2	11.4	11.5	11.8	12.1	12.3	12.6
1974	16.9	16.4	16.0	15.7	15.3	14.8	14.5	14.1	1997	12.5	12.6	12.7	12.8	12.9	13.0	13.0	13.1
1975	15.2	15.1	15.0	14.8	14.6	14.3	14.1	13.9	1998	11.2	11.4	11.6	11.8	12.1	12.3	12.5	12.8
1976	14.7	14.7	14.7	14.6	14.4	14.2	14.0	13.8	1999	10.9	11.1	11.3	11.5	11.8	12.1	12.4	12.6
1977	14.8	14.8	14.7	14.6	14.5	14.2	14.1	13.8	2000	10.7	10.7	10.9	11.1	11.4	11.8	12.1	12.4
1978	16.5	16.2	15.9	15.6	15.2	14.8	14.5	14.1	2001	7.4	8.0	8.6	9.1	9.7	10.5	11.0	11.7
1979	18.6	17.7	17.1	16.6	16.0	15.3	14.9	14.4	2002	4.9	5.9	6.8	7.6	8.5	9.6	10.3	11.2
1980	17.4	16.4	15.8	15.4	15.0	14.5	14.2	13.9	2003	3.5	4.7	5.7	6.6	7.6	8.9	9.8	10.8
1981	21.6	20.0	18.9	18.1	17.2	16.2	15.6	14.9	2004	4.0	5.1	6.1	6.9	7.9	9.1	9.9	11.0
1982	17.3	16.6	16.0	15.6	15.1	14.7	14.4	14.0	2005	5.9	6.6	7.3	7.9	8.7	9.8	10.5	11.3
1983	15.2	14.8	14.5	14.3	14.0	13.8	13.7	13.6	2006	8.8	9.1	9.5	9.9	10.4	11.0	11.5	12.0
1984	16.5	15.7	15.2	14.9	14.6	14.2	14.0	13.8	2007	10.9	11.1	11.4	11.6	11.9	12.2	12.4	12.7
1985	16.6	16.2	15.9	15.6	15.2	14.8	14.5	14.1	2008	7.9	8.7	9.3	9.8	10.4	11.1	11.5	12.1

Figures 2 through 6

These figures present each period's 30 year term structure of cost of equity capital as estimated by equation (13)

Figure 2: 1963 – 1969

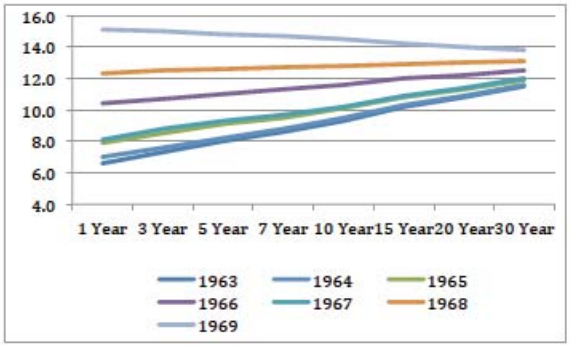

Figure 3: 1970 - 1979

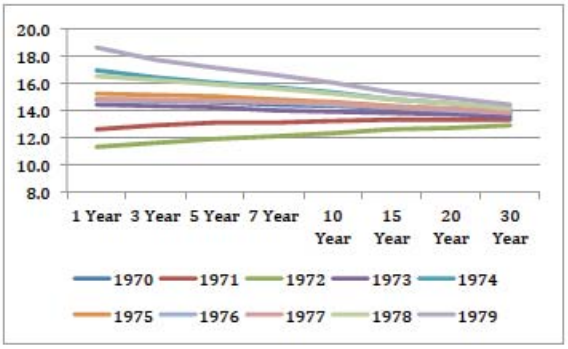

Figure 4: 1980 – 1989

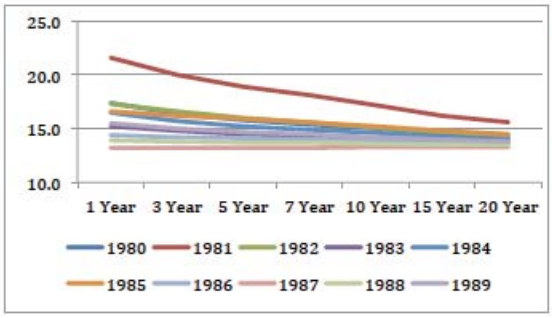

Figure 5: 1990 - 1999

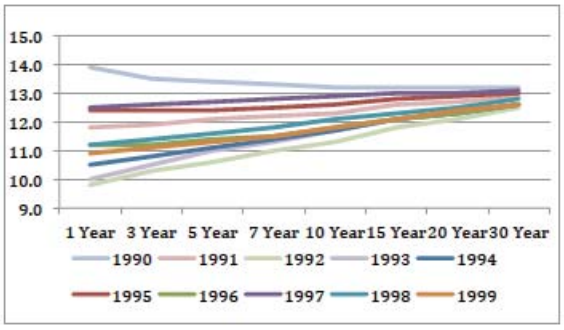

Figure 6: 2000 - 2008

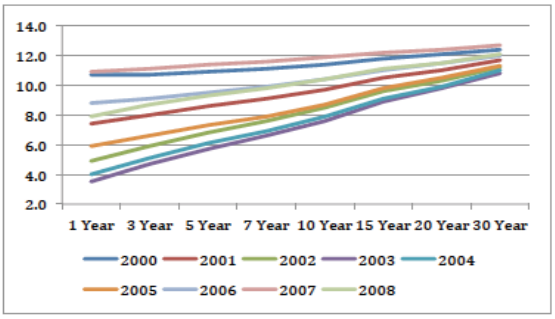

Table IV

Mispricing Error From Static Cost of Equity

This table presents the valuation of a 30 year annuity of an expected cash flow of $1.00 received at the end of each year. We compare the values obtained using the cost of equity capital determined by the static CAPM and the Fama-French 3 Factor model to the values obtained using the term structure of cost of equity capital. The valuation error is calculated as follows (Static Valuation – TS Valuation)/TS Valuation.

	Annuity Value			Valuation Error			
				CAPM		Fama French 3 Factor	
Year	TS	CAPM	FF	Pct Error	ABS(Error)	Pct Error	ABS(Error)
1963	12.98	10.72	11.17	-21.08%	21.08%	-13.95%	13.95%
1964	12.44	10.51	10.97	-18.31%	18.31%	-11.81%	11.81%
1965	11.33	9.89	10.00	-14.64%	14.64%	-11.81%	11.81%
1966	9.14	8.56	8.49	-6.74%	6.74%	-7.18%	7.18%
1967	11.11	9.74	9.45	-14.07%	14.07%	-14.95%	14.95%
1968	7.86	7.69	8.37	-2.22%	2.22%	6.48%	6.48%
1969	6.54	6.68	7.80	2.00%	2.00%	19.13%	19.13%
1970	6.63	6.78	7.76	2.16%	2.16%	17.02%	17.02%
1971	7.72	7.49	8.51	-3.18%	3.18%	10.13%	10.13%
1972	8.52	8.08	8.83	-5.52%	5.52%	3.65%	3.65%
1973	6.82	6.95	7.61	1.88%	1.88%	11.56%	11.56%
1974	5.87	6.20	7.89	5.31%	5.31%	34.27%	34.27%
1975	6.49	6.63	8.48	2.15%	2.15%	30.78%	30.78%
1976	6.71	6.76	8.61	0.74%	0.74%	28.45%	28.45%
1977	6.65	6.73	8.81	1.13%	1.13%	32.45%	32.45%
1978	5.99	6.27	7.85	4.47%	4.47%	31.15%	31.15%
1979	5.35	5.81	6.82	7.96%	7.96%	27.46%	27.46%
1980	5.71	6.23	7.23	8.29%	8.29%	26.59%	26.59%
1981	4.62	5.22	6.45	11.50%	11.50%	39.57%	39.57%
1982	5.72	6.18	7.41	7.48%	7.48%	29.65%	29.65%
1983	6.49	6.79	8.45	4.39%	4.39%	30.19%	30.19%
1984	6.01	6.46	8.34	6.98%	6.98%	38.79%	38.79%
1985	5.96	6.26	8.23	4.72%	4.72%	38.04%	38.04%
1986	6.82	6.97	10.04	2.05%	2.05%	47.16%	47.16%
1987	7.41	7.38	11.27	-0.43%	0.43%	52.18%	52.18%
1988	7.05	7.14	10.84	1.20%	1.20%	53.66%	53.66%
1989	6.36	6.70	9.32	5.08%	5.08%	46.65%	46.65%
1990	7.04	7.27	9.88	3.26%	3.26%	40.35%	40.35%
1991	8.16	7.96	10.24	-2.41%	2.41%	25.61%	25.61%
1992	9.54	8.80	10.76	-8.44%	8.44%	12.76%	12.76%
1993	9.45	8.61	11.54	-9.68%	9.68%	22.18%	22.18%
1994	9.01	8.50	11.06	-6.05%	6.05%	22.66%	22.66%
1995	7.83	7.75	9.85	-0.94%	0.94%	25.86%	25.86%
1996	8.54	8.33	10.18	-2.60%	2.60%	19.16%	19.16%
1997	7.78	7.63	10.66	-1.98%	1.98%	36.93%	36.93%
1998	8.54	8.21	11.53	-4.10%	4.10%	34.99%	34.99%
1999	8.79	8.38	10.44	-4.92%	4.92%	18.77%	18.77%
2000	8.92	8.60	10.25	-3.76%	3.76%	14.82%	14.82%
2001	11.97	10.24	11.38	-16.80%	16.80%	-4.88%	4.88%
2002	15.63	11.79	11.82	-32.51%	32.51%	-24.39%	24.39%
2003	18.32	12.94	12.02	-41.53%	41.53%	-34.38%	34.38%
2004	17.25	12.55	12.14	-37.46%	37.46%	-29.61%	29.61%
2005	13.94	11.31	11.07	-23.30%	23.30%	-20.63%	20.63%
2006	10.42	9.52	10.57	-9.42%	9.42%	1.44%	1.44%
2007	8.77	8.34	10.37	-5.17%	5.17%	18.15%	18.15%
2008	11.33	9.72	11.62	-16.62%	16.62%	2.56%	2.56%
	Mean			-5.03%	8.62%	16.91%	24.45%
	Median			-2.31%	5.12%	20.67%	25.00%

Figure 12
Average Term Structure Cost of Equity Spread Per Term

This figure presents the average spread above the U.S. Treasury rate for each term (1, 3, 5, 7, 10, 15, 20, and 30 years) for the cost of equity capital term structure.

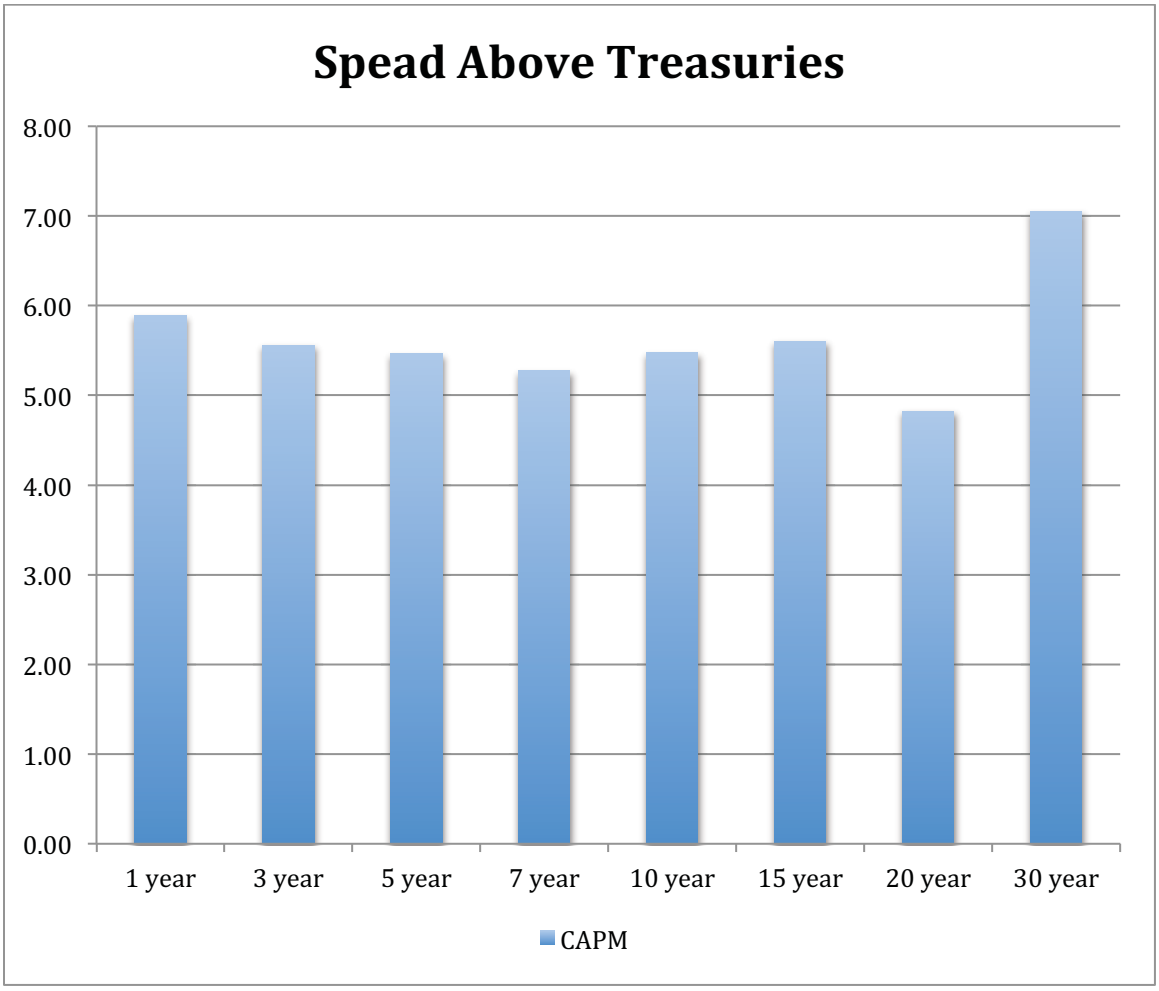

Table V

Research and Development Investment and Cost of equity

This table presents the results of regressing aggregate industry RDS on either the industry cost of equity (when using a static cost of equity model) or the spread between the 1 year and 30 year rates (when using the term structure model). The static model is presented in the first two columns and use the following regression equation: $RDS_t = \alpha + COC_{j,t} + \varepsilon_t$. Where RDS_t is the aggregate industry investment in research and development scaled by aggregate industry sales for year t, and $COC_{j,t}$ is the cost of equity for year t calculated using method j - either CAPM, or Fama-French. Finally, the column evaluate the following regression equation $RDS_t = \alpha + \beta_1(SPREAD_t)$. Where $SPREAD_t$ is the 30 year cost of equity minus the 1 year cost of equity for year 't' as presented in the term structure of cost of equity model.

Method used to calculate cost of equity capital			
RDS = Dependent Variable	**CAPM**	**FF3F**	**Term Structure**
Intercept	0.0553	0.0604	0.0472
	(0.000)	(0.000)	(0.000)
CAPM Cost of Equity Capital	-0.0620		
	(0.034)		
Fama-French 3 Factor Cost of Equity		-0.1254	
		(0.000)	
Term Structure Spread			0.0770
			-0.0450
F-Value	4.79	15.63	4.26
	(0.034)	(0.000)	(0.045)
R-Squared	0.10	0.26	0.09
Adj. R-Squared	0.08	0.25	0.07

Table VI

Research and Development Investment and Cost of equity

This table presents the results of regressing the number of firms issuing equity in a given year on either the industry cost of equity (when using a static cost of equity model) or the spread between the 1 year and 30 year rates (when using the term structure model). The static model is presented in the first two columns and use the following regression equation: $ISSUE_t = \alpha + COEC_{j,t} + \varepsilon_t$. Where $ISSUE_t$ is the number of firms in our sample issuing equity in year t and $COC_{j,t}$ is the cost of equity for year t calculated using method j - either CAPM, or Fama-French. Finally, the last column evaluates the following regression equation $ISSUE_t = \alpha + \beta_1(SPREAD_t)$. Where $SPREAD_t$ is the 30 year cost of equity minus the 1 year cost of equity for year 't' as presented in the term structure of cost of equity model.

Method used to calculate cost of equity capital			
ISSUE = Dependent Variable	**CAPM**	**FF3F**	**Term Structure**
Intercept	12.5280	11.8100	5.9232
	(0.000)	(0.000)	(0.000)
CAPM Cost of Equity Capital	-50.1490		
	(0.001)		
Fama-French 3 Factor Cost of Equity		-53.9300	
		(0.006)	
Term Structure Spread			64.0510
			(0.001)
F-Value	12.45	8.44	11.64
	(0.001)	(0.006)	(0.001)
R-Squared	0.22	0.16	0.21
Adj. R-Squared	0.20	0.14	0.19